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SUGARBEET RESEARCH

2003 REPORT

FOREWARD

SUGARBEET RESEARCH is an annual compilation of progress reports concerning research by U.S. Department of Agriculture, Agricultural Research Service investigators and other cooperators who are engaged in sugarbeet research. The report was assembled and produced at the expense of the Beet Sugar Development Foundation, and is for the sole use of its members and the cooperators. Much of the data has not been sufficiently confirmed to justify general release and interpretations may be modified with additional experimentation. This report is not intended for publication and should not be used for cited reference nor quoted in publicity or advertising. Reproduction of any portion of the material contained herein will not be permitted without the specific consent of the contributor and the Beet Sugar Development Foundation.

The report presents results of investigations strengthened by contributions received under Cooperative Agreement between the USDA Agricultural Research Service and the Beet Sugar Development Foundation, along with the California Beet Growers Association, the Western Joint Research Committee, and the Sugarbeet and Education Board of Minnesota and North Dakota.

Trade names occur in this report solely to provide specific information and do not signify endorsement by the U.S. Department of Agriculture, the Beet Sugar Development Foundation or any of the cooperating organizations.

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SUGARBEET RESEARCH

2003 REPORT

Section A

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     Spreckels Sugar Division
     California Beet Growers Association
     California Industry Research Committee
     Western Sugar Growers Research Committee

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ABSTRACTS OF PAPERS PUBLISHED OR APPROVED FOR PUBLICATION, 2003

BIANCARDI, E., R.T. LEWELLEN, M. DeBIAGGI, and A.W. ERICHSEN. 2002. Le origini della resistenza alla rhizomania. L'Industria Saccarifera Italiana. XCV: 183-195.

In the last 35 years, breeding has greatly reduced the damages caused by rhizomania in sugar beet crop. After the first encouraging results using the Alba genotypes, the variety Rizor represented a substantial step forward and has given good yield improvement in diseased fields in many parts of the world. The original variety and subsequent improved versions continued to offer good performances for about a decade, after which it was surpassed by other hybrids derived in part from the Rizor itself. Further progress in terms of sugar production became possible in 1986 when the Holly monogerm lines were released in USA and Europe. In spite of the incomplete information about the genealogy of the first resistant materials, many evidences and the molecular analyses on the different genotypes suggest a possible common progenitor and lineage. The resistant cultivars have kept the yield at an adequate level, allowing cultivation to continue in countries where the disease has reached epidemic proportions. The case of rhizomania resistance in sugar beet can therefore be considered as one of the most important achievements in plant breeding.

De BIAGGI, M., A.W. ERICHSEN, R.T. LEWELLEN, and E. BIANCARDI. 2003. The discovery of the rhizomania resistance traits in sugar beet. Proc. 1st Joint IIRB-ASSBT Congress, Feb. 27-March 1, 2003, San Antonio, TX. pp.131-147.

Previously recognized as soil sickness or confused with other sugar beet diseases, the symptoms of rhizomania (in its current meaning) were known in several European countries well before the Second World War. Its rapid spreading was noticed in Italy after 1946, and few years later sporadic symptoms of the disease were observed over 10,000 hectares in areas of intense cultivation. Without knowing the true pathogenic factor, some prophylactic measures were adopted: (1) avoid excess water; (2) avoid spreading of contamination through machinery and tare soil; (3) early harvesting in diseased fields; (4) sowing Italian variety with high sugar content. The last advice was established after a number of field trials that included different commercial varieties. Later became evident that the best entries carried the quantitative resistance named "Alba type." Around 1965, the pathologists involved in such researches could establish that the rhizomania was caused by an atypical fungus-virus symbiosis. With this discovery, the disease was correctly explained, and the word rhizomania became used over many important sugar beet production countries. In the 1970's, both the rapid diffusion of the disease and the worsening of the damages on sugar yield pushed many research institutes and seed companies to find more efficient control measures. After years of searching, two monogenetic traits now known as "Rizor type" and "Holly type" were identified and commercially exploited in Italy (1983) and in U.S.A. (1986), respectively. For both countries, the full and particular background of the discovery of the different rhizomania resistances is given by the breeders involved.

KAFFKA, S.R., R.T. LEWELLEN, and W. M. WINTERMANTEL. 2003. Beet curly top virus, insecticides and plant resistance. J. Sugar Beet Res. 40: 145-146.

Beet curly top virus (BCTV), a gemini virus remains a problem for farmers in the San Joaquin Valley of California. It is spread by the beet leaf hopper (*Circulifer tenellus* Baker), which has become naturalized. Recent dependence on non-tolerant sugar beet cultivars had led to increased concern about the potential for a BCTV epidemic, particularly in overwintered crops, which are planted when conditions for infection are greatest. Three trials were carried out in successive years in the western San Joaquin Valley to test the effects of alternative insecticides for control of BCTV on susceptible and tolerant sugar beet cultivars. Two rates of imidicloprid applied as a seed treatment (45 g and 90 g a.i. per 100,000 seeds) were compared to the current standard treatment of phorate applied to soil at 83.8 g a.i. per 1000 m of row, and an untreated control. In the third trial, clothianidan was also used at the rate of 15 g a.i. per 100,000 seeds. Cultivars ranged in tolerance from the most tolerant line available to the most susceptible cultivar ever observed. In the third trial, different planting dates were also compared. Natural BCTV infection occurred in all three years. Sugar beet root and sugar yields declined linearly with increasing rates of infection. Yields declined because roots were significantly smaller with the non-tolerant cultivar and root populations were reduced by plant loss. Sugar percentage was unaffected by treatments, but differed by cultivar. Imidicloprid and phorate provided similar levels of protection to plants, but were not able to prevent large yield losses among susceptible cultivars when infection occurred early in crop development. Plant resistance provided more effective protection than systemic insecticides.

KOIKE, S.T., D.M. HENDERSON, C.T. BULL, P.H. GOLDMAN, and R.T. LEWELLEN. 2003. First report of bacterial leaf spot of Swiss chard caused by *Pseudomonas syringai* p.v. *apata* in California. Plant Dis. 87: 1397.

From 1999 through 2003, a previously unreported disease was found on commercial Swiss chard (*Beta vulgaris* subsp. *cicla*) in the Salinas Valley, (Monterey County) California. Each year the disease occurred sporadically throughout the long growing season from April through September. Initial symptoms were water-soaked leaf spots that measured 2 to 3 mm in diameter. As disease developed, spots became circular to ellipsoid, 3 to 8 mm in diamter, and tan with distinct brown-to-black borders. Spots were visible from the adaxial and abaxial sides. Cream-colored bacterial colonies were consistently isolated from spots. Strains were fluorescent on King's medium B, levan positive, oxidase negative, and arginine dihydrolase negative. Strains did not rot potato slices but induced a hypersensitive reaction on tobacco (*Nicotiana tabacum* cv. Turk). The isolates, therefore, belong in LOPAT group 1. Fatty acid methyl esters (FAME) analysis (MIS-TSBA version 4.10, MIDI Inc., Newark, DE) gave variable results that included *Pseudomonas syringae, P.cichorii,* and *P.viridiflava* with similarity indices ranging from 0.91 to 0.95. BOX-polymerase chain reaction (PCR) analysis gave identical banding patterns for the chard isolates and for known *P.syringae* pv. *aptata* strains, including the pathotype strain CFBP1617. The bacteria were identified as *P.syrigae*. Pathogenicity of 11 strains was tested by growing inoculum in nutrient broth shake cultures for 48 h. diluting to 10 x 6 CFC/ml, and spraying onto 5-week-old plants of Swiss chard cvs. Red, White, Silverado, and CXS2547. Untreated control plants were sprayed with sterile nutrient broth. After 7 to 10 days in a greenhouse (24 to 26°C), leaf spots similar to those observed in the field developed on all

inoculated plants. Strains were reisolated from the spots and identified as *P.syringae*. Control plants remained symptomless. To investigate the host range of this pathogen, the same procedures were used to inoculate three strains onto other Chenopodiaceae plants: five cultivars of sugar beet (*B. vulgaris*), and one cultivar each of spinach (*Spinacia oleracea*) and Swiss chard. In addition, five chard strains and strain CFBP1617 were inoculated onto two cultivars of sunflower (*Helianthus annuus*), and one cultivar each of cantaloupe (*Cucumis melo*), sugar beet, spinach, and Swiss chard. All Swiss chard, cantaloupe, sunflower, and sugar beet plants developed leaf spots after 7 days. The pathogen was reisolated from spots and confirmed to be the same bacterium using BOX-PCR analysis. Spinach and untreated controls failed to show symptoms. All inoculation experiments were done at least twice and the results were the same. The phenotypic data, fatty acid and genetic analyses, and pathogenicity tests indicated that these strains are *P.syringae* pv. *aptata*. To our knowledge this is the first report of bacterial leaf spot of commercially grown Swiss chard in California caused by *P.syringae* pv. *aptata*. The disease was particularly damaging when it developed in Swiss chard fields planted for "baby leaf" fresh market products. Such crops are placed on 2-m wide beds, planted with high seed densities, and are sprinkler irrigated. This disease has been reported from Asia, Australia, Europe, and other U.S. states.

LEWELLEN, R.T. 2004. <u>Registration of rhizomania resistant, monogerm populations C869 and C869CMS sugarbeet.</u> Crop Sci. 44: 357-358.

Sugar beet (*Beta vulgaris* L.) population C869 (Reg. no. GP-226, PI 628754) and its cytoplasmic male-sterile (CMS) counterpart C869CMS (Reg. no. GP-227, PI 628755) were developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation and the California Beet Growers Association. These lines were released in 2002.

C869 is a monogerm (*mm*), O-type, self-fertile (S^f), genetic-male-sterile ($A\_:aa$) facilitated, random mated population. It segregates for resistance to rhizomania (caused by *Beet necrotic yellow vein* virus) conditioned by the *Rz*1 allele. It has mostly red (*R*) hypocotyls. It is moderately resistant to *Beet curly top virus* (BCTV). C869 has wide variability for reaction to bolting, Erwinia rot (caused by *Erwinia carotovora* subsp. *betavasculorum* Thomson et al.) and powdery mildew (caused by *Erysiphe polygoni* DC.). C869 is an N-type for sucrose concentration with average sugar yield combining ability.

C869CMS is the cytoplasmic male sterile counterpart of C869. It will facilitate rapid development of CMS equivalents of lines extracted or developed from C869. It may also be useful as a monogerm, CMS tester to evaluate multigerm lines for general combining ability.

C869 is a moderately diverse population with good monogerm and O-type traits. It produces vigorous plants and high seed yield. Before 1995, the germplasm base of C869 involved development and recombining subpopulations and selected progeny lines from various sources. Collectively, C869 comprises about 44% of its germplasm from C790 (PI515964) (Lewellen and Skoyen, 1988) through C890 (PI593700) (Lewellen, 1998); 12.5% from C310 (C6) (PI590873) (Lewellen and Skoyen, 1988); 12.5% from BCTV and Erwinia resistant monogerm inbred C1546 (PI590649) (McFarlane and Skoyen, 1965); and about 31% from the original source of *Rz*1 (Biancardi et al., 2002). C790 was a broad based monogerm, self-fertile population that had

undergone five cycles of S$_1$ progeny recurrent selection for sugar yield and was the source of monogerm inbreds such as C790-15 (PI564758) (Lewellen, 1994). C310 was a monogerm, self-fertile population that had proven valuable as a source of *Lettuce infectious yellows* virus resistant parental lines, e.g., C301 (PI590717) (Lewellen and Skoyen, 1987). Since 1995 when population 867 [(C310 x C546)aa x Rz source] and C890 were combined to form 5869, the progenitor of C869, four cycles of selection have been completed. These included individual and combined selections for monogerm, rhizomania resistance, O-type, resistance to Erwinia, powdery mildew, bolting, and for higher sucrose content. From these cycles of selection, subpopulations 7869NB, 7869, and 8869 were formed. Mother root selections from these were recombined in 1999 to produce 9869. In 2000, high quality, monogerm plants of 9869 were selfed to produce selfed progeny families. These families were indexed for O-type and separately evaluated for resistance to rhizomania. About 600 plants from 24 selfed families (i.e., 24 S$_o$ plants) that appeared to be O-type and had resistance to rhizomania were recombined through their genetic male sterile segregants to produce 1869. Seed of 1869 is being released as C869. In 1996, plants of 5869 were increased through their male sterile segregants to produce 6869. Population 6869 was not used directly to produce C869 but was made available for genetic research and tentatively called C869 (McGrath et al., 1999).

C869 and C869CMS should be useful as a source of resistance to rhizomania, BCTV, and other diseases in a monogerm, O-type background. Sufficient genetic variability should remain to permit continued population improvement and development of potential parental lines. C869 may be useful also as a base population from which to develop additional populations and breeding lines and from which to develop selfed progeny for mapping molecular markers. U.S. Plant Variety Protection will not be sought for these lines.

LEWELLEN, R.T. 2004. Registration of sugarbeet germplasm lines C67/2, C69/2, C78/3, and C80/2 with resistance to virus yellows and rhizomania. Crop Sci. 44: 358-359.

Sugarbeet (*Beta vulgaris* L.) germplasm lines C67/2 (Reg. no. GP-229, PI628750), C69/2 (Reg. no. GP-230, PI628751), C78/3 (Reg. no. GP-231, PI628752), and C80/2 (Reg. no. GP-232, PI628753) were developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation and the California Beet Growers Association. These lines were released in 2002. These are self-sterile (S^sS^s), multigerm (*MM*) lines that segregate for resistance to rhizomania caused by *Beet necrotic yellow vein virus*. Resistance to rhizomania is conditioned by *Rz1*. These lines have predominantly red (*R*) hypocotyls. Earlier versions of these lines have been released. They encompass a broad cross section of the "Salinas" multigerm, germplasm base. The origin and development of these breeding lines span 20 to 60 years of breeding efforts for improvements in productivity and combined disease resistance. Sugar yields tend to be primarily of the N-type but full-sib and other types of progeny tests have shown wide genetic variability for components of productivity. Selection pressure has been exerted to improve resistance to virus yellows caused by the *Beet yellows virus*, *Beet western yellows virus*, and *Beet chlorosis virus* complex; *Erwinia carotovora betavasculorum; Erysiphe polygoni*, the cause of powdery mildew; rhizomania; *Peronospora farinoso*, the cause of downy mildew; and *Uromyces betae*, the cause of rust.

C67/2 was selected from C67 (PI599340) released in 1998. Since that release, C67/2 has undergone two additional cycles of recurrent phenotypic selection. In both cycles, emphasis was placed on selecting mother roots for sucrose concentration, size, and conformation from plants grown in the field under rhizomania conditions, inoculated with virus yellows and sugarbeet *Erwinia*, and naturally infected with powdery mildew. Plants that bolted before harvest were eliminated. C67/2 is estimated to have about 10% of its germplasm from *B. vulgaris* subsp. *maritima* (*Bvm*). The *Bvm* germplasm was derived from R322Y3%, a component of C51 (PI593694) (Lewellen, 2000b), that had been selected for combined resistance to rhizomania, virus yellows, and agronomic traits. The sugarbeet germplasm was largely from C37 (PI590715) (Lewellen et al., 1985b), C78 (PI593671) (Lewellen, et al., 1985a), C80 (PI593672) (Lewellen, 1997), and C82 (PI593675) (Lewellen, 1997). Resistance to rhizomania is conditioned by both *Rz* and factor(s) from C51 (*Bvm*) that gives a high level of resistance under high temperature conditions. During its development C67/2 has been tested as Y967 and Y167.

C69/2 was selected from C69 (PI599341) released in 1998 (Lewellen, 2000a). Since then, C69/2 has undergone two additional cycles of recurrent phenotypic selection. In both cycles, emphasis was on selecting mother roots for sucrose concentration, size, and conformation from field plants grown under rhizomania conditions, inoculated with virus yellows and sugarbeet *Erwinia*, and naturally infected with powdery mildew. C69/2 is predominantly the germplasm of C31/6 (PI590799) (Lewellen et al., 1978) with smaller amounts from C37, C46/2 (PI590800), C39 (PI583373) (Lewellen, 1995), C64 (McFarlane et al., 1965), and other sources. C69/2 is moderately resistant to virus yellows, bolting, powdery mildew, and *Erwinia*. It is moderately susceptible to curly top. During its development, C69/2 has been tested as breeding line numbers Y969 and Y169.

C78/3 was selected from C78/2 (PI593695) released in 1996 and C78 (PI593671) released in 1994 (Lewellen, 1997). Since being released as C78/2, C78/3 has undergone three additional cycles of recurrent phenotypic selection. In each cycle, emphasis was on selecting mother roots for sucrose concentration, size, and conformation from field plants grown under rhizomania conditions, inoculated with virus yellows and sugarbeet *Erwinia*, and naturally infected with powdery mildew. C78/3 is predominantly the germplasm from curly top resistant breeding line C46/2 (PI590800) (Lewellen et al., 1985a). C78/3 is moderately resistant to virus yellows, bolting, powdery mildew, Erwinia, and curly top. During its development, C78/3 has been tested as breeding line numbers R578, R578/2, R578%, R778, R778%, R978 and R178. Although handled as if completely self-sterile (*S⁵ S⁵*), recent use of C78/3 progenitors as a recurrent parent in backcrossing programs has shown that some plants expressed varied degrees of self-fertility.

C80/2 was selected from C80 (PI593672) (Lewellen, 1997), C80NB (PI593673), and C80-45 (PI593674) released in 1994. These sublines were recombined to produce C80/2. C80/2 has undergone four additional cycles of recurrent phenotypic selection. The first of these four cycles was for resistance to rhizomania in 4-month old plants within C80, C80NB, and C80-45. Selected plants from these lines were recombined into one population. In each of the next three cycles, emphasis was placed on selecting mother roots for sucrose concentration, size, and conformation from field plants grown under rhizomania conditions, inoculated with virus yellows and sugarbeet *Erwinia*, and naturally infected with powdery mildew. C80/2 was developed from a broad base of breeding lines in the virus yellows and multiple disease

resistance program at Salinas. During its development, C80/2 has been tested as breeding line numbers R580, R580-45, R580NB, R780/2, R780-45, R980, and R180.

Lines C67/2, C69/2, C78/3, and C80/2 may be useful for continued line improvement and as sources of multiple disease resistant germplasm. These four lines represent a broad germplasm base and encompass much of the germplasm developed in the long term breeding program at Salinas. They account for much of the germplasm from the virus yellows (BYV/BWYV) breeding program that has been ongoing since 1955. Based upon previous successes and evidence from progeny family evaluations (both S_1 and full sib), these lines may continue to be useful as sources from which to extract parental lines. U.S. Plant Variety protection will not be sought for these lines.

LEWELLEN, R.T. 2004. Registration of sugarbeet germplasm lines C927-4, C929-62, C930-19, and C930-35 with resistance to rhizomania, virus yellows, and bolting. Crop Sci. 44: 359-361.

Sugarbeet (*Beta vulgaris* L.) germplasm lines C927-4 (Reg. no. GP-233, PI628756), C929-62 (Reg. no. GP-234, PI628757), C930-19 (Reg. no. GP-235, PI628758), and C930-35 (Reg. no. GP-236, PI628759) were developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation and the California Beet Growers Association. These lines were released in 2002. They are narrowly based each having been increased from one S_1 progeny (one selfed S_0 plant). They are multigerm (*MM*), self-fertile (S^f) diploids that segregate for genetic male sterility (*aa*) and resistance to rhizomania conditioned by *Rz1*. They have shown good general combining ability for sugar yield in experimental hybrids. In general, they show nonbolting tendency in over-wintered plantings and have tolerance to virus yellows (VY), caused by *Beet yellows virus* (BYV), *Beet western yellows virus* (BWYV), and *Beet chlorosis virus* (BChV). Except for the intermediate reaction for C930-35, all show high resistance to sugarbeet *Erwinia*, caused by *E. carotovora betavasculorum*.

Lines C927-4, C929-62, C930-19, and C930-35 were identified and selected from a program designed to combine multiple disease resistance and factors for productivity. S_1 progeny evaluations followed by testcross hybrid evaluations were used. S_1 progeny evaluation is a useful plant breeding method for identifying and improving traits with additive genetic variance, e.g., most disease resistances and sucrose concentration. Breeding lines with self-incompatibility (S^sS^s) comprise most of the advanced, highly productive sugarbeet germplasm, however, they do not easily lend themselves to this breeding procedure. The program from which these lines were selected was designed to determine if self-incompatible lines could be worked quickly into an S_1 testing program. To accomplish this, self-incompatible lines were crossed onto genetic-male-sterile plants from self-fertile, genetic-male-sterile facilitated, random-mated populations that had been undergoing population improvement. These F_1 population or line hybrids were then used as the source of the S_0 plants to produce S_1 progenies. Because seed of population hybrids can be easily produced in large quantities, the S_0 plants can be selected after rigorous evaluation for one or more moderate to highly heritable traits. In this scheme, most of the S_0 plants will be pollen fertile (*Aa*) and their S_1 progenies will segregate $3A\_:1aa$, giving ample opportunity and flexibility for selecting materials to be used in a continuing line or population improvement program. With the exception of C930-19, only 6 years were needed to go from the initial crosses

to early generation lines with potential for development into parental lines for C927-4, C929-62, and C930-35.

C927-4 segregates for hypocotyl color (R). In addition to resistance to rhizomania conditioned by $Rz1$, resistance is also provided from factor(s) from *B. vulgaris* subsp. *maritima* (*Bvm*). C927-4 produces hybrids with intermediate sucrose concentration and high sugar yield. Relative performance of these hybrids is best when grown under rhizomania conditions. C927-4 is moderately susceptible to powdery mildew and curly top virus.

C927-4 was derived from a population cross between populations C918 (PI578079) (USDA, 1993) and 921. C918 is a multigerm, self-fertile, genetic-male-sterile facilitated, random-mated population. Self-fertile population 921 was developed from crosses between C918 and self-sterile lines R322Y3 and R322R4. Lines R322Y3 and R322R4 are similar to C51 (PI593694) (improved C50, PI538251) (Lewellen, 2000) that was developed from composite crosses between sugarbeet and *Bvm*. Theoretically, about 12% of C927-4 would be from *Bvm*. Population C918 is a source for the $Rz1$ allele for resistance to rhizomania. C51 contributed additional factors that condition improved resistance and survivability of plants under the combined effects of severe rhizomania and high temperature stress. C927-4 possesses this type of resistance to rhizomania. From the F_1 population hybrid between genetic-male-sterile plants from C918 and fertile plants from 921, individual S_0 plants were selected for sucrose concentration under virus yellows (VY) inoculated (BYV/BWYV/BChV) conditions and selfed under bags to produce S_1 progeny families. These S_1 progenies were evaluated for resistance to rhizomania at Salinas and Brawley, CA, for performance under VY inoculated conditions at Salinas and Davis, CA and for bolting tendency at Salinas. On the basis of these tests, S_1 progenies were selected, increased in isolation, and testcrossed to a monogerm, cytoplasmic male-sterile line. Line 9927-4VY was selected based on the performance of its experimental hybrid and increased through its genetic-male-sterile segregants to produce line 1927-4 that was released as C927-4.

C929-62 has red hypocotyls (*RR*) and near seed maturity has reddish stems and seedballs. It has moderately high resistance to powdery mildew and is moderately susceptible to *Curly top virus* and downy mildew caused by *Peronospora farinosa*. C929-62 produces hybrids with intermediate sugar concentration and high sugar yield.

C929-62 was derived from a population cross between genetic-male-sterile plants from population C918 and C76-89-18 (PI593699). Self-sterile line C76-89-18 was advanced from one full-sib progeny that was susceptible to rhizomania but had high sugar yield combining ability and resistance to virus yellows, *Erwinia*, and bolting. It was selected from C31/6 (PI590799) type germplasm. From the F_1 population hybrid, individual S_0 plants were selected for sucrose concentration under VY inoculated conditions and were selfed under bags to produce S_1 progenies. These S_1 progenies were evaluated at Salinas and Davis for performance under virus yellows inoculated conditions and at Salinas for components of sugar yield, resistance to rhizomania, and nonbolting tendency. On the basis of these tests, S_1 progenies were selected, increased, and testcrossed to a monogerm, CMS tester. Line 9929-62VY was selected for further evaluation based on the performance of its experimental hybrid. Line 9929-62VY was increased through its male-sterile segregants to produce line 1929-62 that was released as C929-62.

C930-19 segregates for hypocotyl color. It is moderately resistant to curly top virus and powdery mildew and has very high nonbolting tendency. In tests at Salinas and Brawley, its hybrids have moderate to high sugar concentration and sugar yield.

C930-19 was derived from a population cross made in 1995 between population C918 and breeding line C78 (PI593671). C78 is a rhizomania resistant version of C46/2 (PI590800). Self-sterile C46/2 has moderate curly top resistance and has been an important source of pollinators used commercially in California. From the F_1 population hybrid, individual S_0 plants were selected for resistance to rhizomania and were selfed to produce S_1 progenies. These S_1 progenies were evaluated at Salinas for components of sugar yield and for resistance to bolting, rhizomania, powdery mildew, and virus yellows. On the basis of these tests, S_1 progenies were selected, increased, and testcrossed to a monogerm, CMS tester. Line 8930-19 was chosen from among this group for further evaluation based on the performance of its experimental hybrid. Over-wintered stecklings from Oregon of 8930-19 were transplanted into a field isolation plot at Salinas. In the absence of an artificially extended photoperiod, stecklings of 8930-19 were very slow to bolt and some plants did not flower. During seed harvest, 30 of these non-flowering plants were saved out of an initial 210 stecklings, regrown in the greenhouse, and vernalized for 140 days, then replanted into a greenhouse isolation chamber with a 24-hour photoperiod. Under these conditions, this nonbolting selection from line 8930-19 produced seed. This seed was harvested in bulk without regard to male sterile segregants and called 1930-19. Line 1930-19 was reselected for resistance to rhizomania and selected plants were increased through its genetic-male-sterile segregants to produce 2930-19. Line 2930-19 was released as C930-19.

C930-35 has green hypocotyls (*rr*), is moderately resistant to *Curly top virus* and powdery mildew and has high sucrose concentration. C930-35 produces hybrids with high sugar concentration but moderate root and sugar yields.

C930-35 was derived from a population cross made in 1996 between genetic-male-sterile plants from one component of population CZ25 (PI599343) and breeding line C78. This component of CZ25 was a multigerm, self-fertile, genetic-male-sterile facilitated, random-mated population. It was developed from crosses between breeding sources similar to C918 and high sucrose accessions from Poland. About 25% of the germplasm of C930-35 would be Polish. The Polish germplasm was from $2n = 2x = 18$ chromosome, multigerm, self-incompatible (S^sS^s), type-ZZ lines accessed from Dr. A. Szreder, Hodowla Buraka Cukrowego, Poland, in 1988 for use in the Salinas breeding program. A composite of nine Polish accessions were crossed to genetic-male-sterile plants from a progenitor of population C918 to ultimately produce population CZ25. From the F_1 population hybrid between CZ25 and C78, individual S_0 plants were selected for resistance to rhizomania and were selfed in bags to produce S_1 progenies. These S_1 progenies were evaluated at Salinas for components of sugar yield and resistance to bolting, rhizomania, and powdery mildew. At both Salinas and Davis, they were evaluated for sugar yield under virus yellows inoculated conditions. On the basis of these tests, S_1 progenies were selected, increased, and testcrossed to a monogerm, CMS tester. Line 9930-35 was selected for further evaluation based on the performance of its experimental hybrid. Line 9930-35 was increased through its male-sterile segregants to produce line 1930-35 that was released as C930-35.

Lines C927-4, C929-62, C930-19, and C930-35 may be useful as germplasm sources for further improvements and as sources of combined disease and bolting resistance in highly productive

backgrounds. They need to be evaluated as early generation lines for the potential development of pollinators for commercial hybrids. U.S. Plant Variety Protection will not be sought for these lines.

LEWELLEN, R.T., H.-Y. LIU, W.M. WINTERMANTEL, and J.L. SEARS. 2003. Inheritance of Beet Necrotic Yellow Vein Virus (BNYVV) Systemic Infection in Crosses Between Sugarbeet and *Beta Macrocarpa.* Proc. 1st Joint IIRB-ASSBT Congress, Feb. 27–March 1, 2003, San Antonio, TX. pp. 149-160.

Beet necrotic yellow vein virus (BNYVV), the cause of rhizomania, rarely infects sugarbeet (*Beta vulgaris* L.) systemically. Conversely, from mechanical inoculation BNYVV almost always systemically infects *B. vulgaris* subsp. *macrocarpa* (*B. mac*) line that grows as a weedy annual in the Imperial Valley of California. This *B. mac* has been used for many years in the virology programs at Salinas as an indicator host for virus assays. *B. mac* shows other reactions to viruses that are of interest. When infected young, *Beet yellows*, *Beet mosaic*, and *Beet curly top viruses* kill *B. mac*. Other "nonbeet" viruses, e.g., *Lettuce mosaic virus,* readily produce systemic infection in *B. mac* but not in sugarbeet. It was of interest to determine the genetic basis of these different host-plant reactions. *B. mac* is a very easy bolting annual and highly self-fertile and successful crosses were achieved only when sugarbeet was used as the female. Color patterns and annualism were used as markers to positively identify F_1 hybrids. The very limited number of F_1 plants tested had the virus reaction of sugarbeet or were intermediate. The F_2 suggested that BNYVV systemic infection was conditioned by a homozygous recessive factor but the lack of fit may have been caused by escapes and lethal and sublethal mutant plants and to incomplete expressivity. F_3 population and F_3 line patterns also suggested recessive inheritance, but again ratios appeared disturbed. Most F_3 plants produced from F_2 plants with systemic infection to BNYVV were susceptible to systemic infection and there was no evidence for seed transmission. Evaluation of segregating populations is continuing with the intent to produce a biennial line with the virus reactions of *B. mac* and to determine if different genes for host reaction are involved for each virus or if one recessive factor is predisposing *B. mac* to be widely susceptible to systemic infection by numerous viruses.

LIU, H.-Y., J.L. SEARS, M. BANDLA, A.M. HARNESS, and B. KULEMEKA. 2003. First report of Calibrachoa mottle virus infection petunia. Plant Dis. 87:1538.

Calibrachoa mottle virus (CbMV), a putative *Carmovirus,* was first isolated and reported by Liu et al., (1) from infected *Calibrachoa* plants. During the spring of 2003, petunia samples from Florida and California sent to testing services at Agdia Inc (Elkhart IN) tested positive for CbMV by enzyme-linked immunosorbent assay (ELISA) and lateral flow immunoassay (ImmunoStrips®). These samples also tested positive by both *Carmovirus* group-specific PCR primers and by immunocapture PCR (2). RNA extracted from these samples with the RNeasy Plant Kit (Qiagen Inc., Valencia, CA) hybridized with a digoxigenin labeled probe derived from purified CbMV viral RNA. Among the samples that tested positive for CbMV one symptomatic sample also tested positive for *Tobacco mosaic virus* (TMV). From samples that tested positive for CbMV only, mechanical inoculations were made to *Chenopodium quinoa* at a USDA-ARS greenhouse in Salinas, CA. The representative single local lesions were used to sub-inoculate

additional *C. quinoa* plants. The resulting local lesions from this sub-inoculation were freeze dried and further used as virus inoculum (CbMV petunia). Similar inoculum was made with CbMV isolated from *Calibrachoa* plants (CbMV calibrachoa). Virus-free *Petunia hybrida* cultivars Surfinia® 'Baby Pink' and Surfinia® 'Violet' (Jackson & Perkins Inc., Somis, CA) were mechanically inoculated with both CbMV petunia and CbMV calibrachoa. Four weeks post-inoculation all plants were tested by ELISA for the presence of CbMV. In greenhouse conditions 14.3% of the 'Baby Pink' plants were positive for CbMV petunia whereas none was positive for CbMV calibrachoa. 'Violet' plants were 64.3% and 33.3% positive for CbMV petunia and CbMV calibrachoa, respectively. None of the positive plants expressed virus-like symptoms. Virus particles resembling those of CbMV were observed from infected petunia plants by transmission electron microscopy in leaf-dip preparations. To our knowledge, this is the first report of CbMV infecting petunia. Commercial reproduction of petunia plants and maintenance of genetic mother stock are usually by vegetative propagations. CbMV can be transmitted mechanically and is readily propagated along with its host. In order to produce healthy petunia plants, virus-free mother stock should be used, which requires regular screening of mother stock for CbMV.

LIU, H.-Y., J.L. SEARS, and R.T. LEWELLEN. 2003. A new beny-like sugarbeet virus emerging in the United States. In: Proceedings of joint meeting of the International Institute for Beet Research and American Society of Sugar Beet Technologists, February 26 – March 1, 2003, San Antonio, Texas. pp. 843-847.

A virus with rigid rod-shaped particles was isolated in addition to *Beet necrotic yellow vein virus* (BNYVV) from rhizomania infested fields in California. The infected sugarbeet leaves showed oak-leaf pattern symptoms different from rhizomania. For purposes of discussion this unnamed virus will be tentatively called Beet oat-leaf virus (BOLV). BOLV is serologically distinct from BNYVV, *Beet soil-borne mosaic virus* (BSBMV), and *Beet soil-borne virus* (BSBV)/*Beet virus Q* (BVQ). The host range of BOLV is similar to BNYVV and BSBMV mostly infecting *Chenopodiaceae* plants. BOLV produces chlorotic local lesions with a necrotic ring after mechanical inoculations. Particles were 18 to 20 nm wide and ranged from 80 to 640 nm long with three modal lengths: 180-200 nm, 260-280 nm, and 300-320 nm. *Polymyxa betae* transmission of BOLV was demonstrated through a bioassay by using BOLV-infected cystosori and sugarbeet as bait. BOLV has been purified from *Chenopodium quinoa*. The molecular mass of the capsid protein was estimated to be 43.0 kDa. A polyclonal antibody from rabbits has been produced and can be used in ELISA and immunogold labeling tests. BOLV appears to be wide spread in U.S. It has been found also in Colorado, Michigan, Minnesota, Nebraska, and Wyoming. BOLV was found in sugarbeet alone or co-infected with BNYVV and/or BSBMV. The economic significance of BOLV and its interaction with other benyviruses are not known. LIU, H.-Y., J.L. SEARS, and R.T. LEWELLEN. 2003. *Beet oak-leaf virus – a new Polymyxa betae* transmitted sugar beet virus in the United States. In: Proceedings of 8th International Congress of Plant Pathology, Christchurch, New Zealand, February 2-7, 2003. p268.

An un-named virus isolated from rhizomania infested fields in California. The infected sugar beet leaves showed oak-leaf pattern symptoms different from rhizomania. This virus will be tentatively called Beet oat-leaf virus (BOLV). BOLV is serologically distinct from *Beet necrotic yellow vein virus* (BNYVV), *Beet soil-borne mosaic virus* (BSBMV), and *Beet soil-borne virus* (BSBV). The host range of BOLV is similar to BNYVV and BSBMV mostly infecting *Chenopodiaceae* plants.

BOLV produces chlorotic local lesions with a necrotic ring after mechanical inoculations. Particles were 18 to 20 nm wide and ranged from 80 to 640 nm long with three modal lengths: 180-200 nm, 260-280 nm, and 300-320 nm. *Polymyxa betae* transmission of BOLV was demonstrated through a bioassay by using BOLV-infected cystosori and sugarbeet as bait. BOLV has been purified from spinach (*Spinacia oleracea*) plants. The molecular mass of the capsid protein was estimated to be 48.0 kDa. A polyclonal antibody from rabbits has been produced and can be used in ELISA and immunogold labeling tests. BOLV appears to be wide spread in the U.S. It has been found also in Colorado, Michigan, Minnesota, Nebraska, and Wyoming. BOLV was found in sugar beet alone or co-infected with BNYVV and/or BSBMV. The economic significance of BOLV and its interaction with other benyviruses are not known.

LIU, H. Y., J.L. SEARS, and R.T. LEWELLEN. 2003. Study of *Beet necrotic yellow vein virus* pathotypes in California. Phytopathology 93:S54.

Rhizomania is one of the most economically important diseases of sugar beet. This disease is caused by *Beet necrotic yellow vein virus* (BNYVV) and vectored by the soil-borne fungus *Polymyxa betae*. Partially resistant sugar beet cultivars based upon single dominant genes have been developed against this devastating disease. In the summer of 2002, two sugar beet fields with a BNYVV-resistant cultivar in the Imperial Valley of California were observed with severe rhizomania symptoms, suggesting that resistance had been compromised. Standard soil baiting with sugar beet plants followed by ELISA tests were used to diagnose virus occurrence and reaction. Resistant varieties grown in regular BNYVV-infested soil remained resistant. In contrast, when grown in Imperial Valley BNYVV-infested soil all resistant varieties tested susceptible according to elevated ELISA values. Eight different BNYVV isolates have been isolated from Imperial Valley soil (IV-BNYVV) by single local lesion isolation. IV-BNYVV isolates did not contain RNA-5 as determined by RT-PCR. In single-strand conformation polymorphism analyses all the isolates the banding patterns were identical to A-type and different from P-type. From our preliminary results indicate the resistance-breaking BNYVV isolates derived from existing A-type.

McGRATH, J.M. and R.T. LEWELLEN. 2004. Registration of EL 0204 sugarbeet germplasm with smooth-root and resistance to rhizomania. Crop Sci. 44: (in press).

see East Lansing section of Report.

TZANETAKIS, I.E., W.M. WINTERMANTEL, and R.R. MARTIN. 2003. First report of Beet pseudo yellows virus in strawberry: A second crinivirus able to cause pallidosis disease. Plant Disease 87: 1398.

During efforts to characterize strawberry pallidosis disease we identified a single strawberry plant that indexed positive for pallidosis disease by grafting, but was not infected with Strawberry pallidosis associated virus (SPaV) based on RT-PCR(1). Leaves of this plant were regrafted onto *Fragaria vesca* UC-4 and UC-5 and *Fragaria virginiana* UC-10 and UC-11 indicator plants. The *F. vesca* plants remained asymptomatic while the *F. virginiana* plants gave typical pallidosis symptoms that included marginal leaf chlorosis and epinasty. The combination of these symptoms on *F. virginiana* and lack of symptoms on *F. vesca* is used to define pallidosis disease (1). We extracted dsRNA from the original plant, and synthesized and cloned cDNA as previously described (1). Sequence analysis revealed several clones that corresponded to the published sequence of the *Beet pseudo yellows virus* (BPYV) heat shock protein 70 homolog gene (HSP70h). We transferred the isolate to *Nicotiana benthamiana* using the whitefly vector, *Trialeuroides vaporariorum,* and re-isolated and cloned from dsRNA. Here we present the complete sequence of the HSP70h and minor coat protein (CPm) genes of the strawberry BPYV isolate (GenBank accession Nos AY 267369 and AY 268107). Oligonucleotide primers BP CPm F (5' TTCATATTAAGGATGCGCAGA 3') and BP CPm R (5' TGAAAGATGTCCACTAATGATA 3') were designed to amplify a 334 nucleotide fragment of the CPm gene of the strawberry BPYV isolate. Using this primer set we were able to verify the presence of BPYV in one to three year old plants from the major strawberry producing areas of the U.S. including California, Oregon and the Mid-Atlantic States. Infection rates were highest near Watsonville, California where more than 20% of the plants tested were infected with BPYV. This is the first report of BPYV infecting strawberry. BPYV, as well as the recently identified and closely related crinivirus, SPaV (2), pose new concerns for the U.S. strawberry industry. Studies are currently underway to determine the effects of these two viruses on strawberry vigor and productivity.

WEILAND, J.J. and M.H. YU. 2003. A cleaved amplified polymorphic sequence (CAPS) marker associated with root-knot nematode resistance in sugarbeet. Crop Sci. 43:1814-1818.

Resistance to root-knot nematode (*Meloidogyne* spp.) previously was introgressed into sugarbeet (*Beta vulgaris* L.) from wild beet [*B. vulgaris* ssp. *maritima* (L.) Arcang] and was demonstrated to be dominant and simply inherited. Since resistance conferred by this gene was effective against six different species of *Meloidogyne* spp. tested, the locus was designated R6m-1 for resistance to 6 species of *Meloidogyne* spp. Sugarbeet population 1568, an inter-pollinated progeny population of resistant heterozygotes segregating for *R6m-1*, was inoculated with J2 nematodes and rated for root knot disease in a greenhouse. Resistance vs. susceptibility segregated at approximately a 4:1 ratio and 120 resistant roots and 48 susceptible roots were chosen for the generation of a molecular marker linked to the resistance trait. Bulked DNA samples prepared from shoots sprouting from the selected plants were subjected to RAPD analysis, yielding a marker of 600 bp that was highly associated with resistance. Sequence comparison between the product generated from resistant plants and susceptible plants revealed numerous nucleotide substitutions. One base substitution associated in repulsion with resistance

conditioned the existence of a recognition site for cleavage by the restriction endonuclease *Mse* I. Amplification and cleavage of the product with *Mse* I yielded a cleaved amplified polymorphic sequence (CAPS) marker designated Nem06 that segregated 100% with resistance to the root knot nematode.

WINTERMANTEL, W.M. 2004. Pumpkin *(Cucurbita maxima and C. pepo)*, a new host of *Beet pseudo yellows virus* in California. Plant Disease 88: 82.

In the summer of 2002, pumpkin plants (*Cucurbita pepo* L. and *C. maxima* Duchesne) with extensive leaf chlorosis similar to those observed in crinivirus infections were found in fields at two locations in Monterey County, California. Leaves of diseased plants were observed to have large populations of greenhouse whitefly (*Trialeurodes vaporariorum*) present. Double-stranded RNA was extracted from symptomatic leaves of these plants, and tested by Northern hybridization for numerous criniviruses. A positive signal was identified exclusively with probes against the HSP70h gene of *Beet pseudo yellows virus* (BPYV), and confirmed by RT-PCR amplification of a 335 nucleotide section of the BPYV minor coat protein (CPm) gene (3). Similar symptoms were observed in additional fields in 2003, and BPYV was again confirmed. In addition, the CPm RT-PCR product was cloned into a TOPO pCR2 vector (Invitrogen, Carlsbad, CA) and sequenced. BLAST analysis of the cloned CPm RT-PCR product sequence corresponded to the published sequence of the CPm gene of BPYV (98%) (3) and *Cucumber yellows virus* (CuYV), a recently sequenced crinivirus considered to be a strain of BPYV (97%) (2). Incidence of BPYV in pumpkin appears to be variable and probably corresponds to the incidence of viruliferous whiteflies. Based on foliar symptoms, BPYV incidence varied from less than 50% in these fields in 2002, to nearly 100% infection of a large commercial field in 2003. BPYV is transmitted semi-persistently by the greenhouse whitefly and has an extensive host range (1). The virus causes economic losses world-wide for greenhouse vegetable production and is becoming an increasing problem for field crops in areas of high greenhouse whitefly incidence (3). The impact of BPYV on pumpkin production remains to be determined; however, grower data suggests an increased incidence of fruit abortion and a substantial decrease in fruit weight. This is the first report of BPYV infecting pumpkin.

WINTERMANTEL, W.M. and A.G. ANCHIETA. 2003. Tombusvirus infection of lettuce in influenced by soil salinity. Proc. 5th Symposium of the International Working Group on Plant Viruses with Fungal Vectors. Zurich, Switzerland, July 22-25, 2002. pp. 131-134.

A severe soil-borne disease of lettuce has emerged to cause severe losses for lettuce production in the western United States. The disease is caused by a group of tombusviruses, including both *Tomato bushy stunt virus* and the newly described *Lettuce necrotic stunt virus*. Fields with severe infections are usually associated with areas near rivers and areas where flooding has recently occurred. Interestingly, disease severity in infested fields varies considerably from year to year. In order to identify factors contributing to variability in infection, soil analyses were conducted on adjacent fields with similar soil type, but differing for tombusvirus infection. These studies identified soil salinity as the predominant factor differing between diseased and disease-free fields. Subsequent greenhouse studies examined the effect of electrical conductivity levels in the soil on virus infection. Results indicated that elevated electrical conductivity (5.5

dS/cm^3) led to elevated levels of LNSV infection when compared with a lower electrical conductivity (3.2 dS/cm^3), which exhibited very low disease incidence.

WINTERMANTEL, W.M., A.G. ANCHIETA, C. OBERMEIER, and G.C. WISLER. 2003. Tombusvirus infection of lettuce is influenced by the soil environment. Phytopathology 93(6): S101.

Lettuce dieback, a new soil-borne disease of lettuce, emerged in the 1990s to cause severe losses for lettuce production in the western United States. The disease is caused by the recently described tombusvirus, *Lettuce necrotic stunt virus* (LNSV) (Obermeier et al., 2001). LNSV can infect lettuce through the soil in the absence of fungal vectors. Fields with high disease incidence are usually poorly drained, however, disease severity in infested fields varies considerably from year to year. To identify factors contributing to variability in infection, soil analyses were conducted on adjacent lettuce fields with similar soil type, but differing in the presence or absence of LNSV infected lettuce. Complete soil profiles identified soil salinity as the predominant factor differing between diseased and disease-free fields. Greenhouse studies, conducted in well-drained soil, as well as saturated soil, examined the effect of soil salinity on virus infection of lettuce. Results indicate that variation in soil salinity influences LNSV infection of lettuce and the development of lettuce dieback symptoms.

WINTERMANTEL, W.M., A.A. CORTEZ, and A.G. ANCHIETA. 2003. Trialeurodes vaporariorum transmits Tomato chlorosis virus with higher efficiency than Tomato infectious chlorosis virus. Proc. Pan American Plant Disease Conference. South Padre Is., TX, Apr. 5-10, 2003. p 215.

Tomato chlorosis crinivirus (ToCV) and *Tomato infectious chlorosis crinivirus* (TICV) are being found in increasing numbers of locations throughout the world. TICV is transmitted only by *Trialeurodes vaporariorum*, while ToCV is transmitted by *T. vaporariorum* and 3 additional whitefly species. Both criniviruses infect many of the same solanaceous hosts. Increasingly, these viruses are being found together in the same fields, and occasionally in the same host plant. Both viruses have similar genome sizes and organization, suggesting the potential exists for virus interactions. We established *Physalis wrightii* source plants, containing either TICV alone, ToCV alone, or both viruses together, confirmed by northern blot using virus specific probes. *T. vaporariorum* were allowed to feed separately on all virus sources, as well as virus-free plants for 24 hours, then were transferred to young host plants. After 5 weeks, symptomatic plants were tested by northern blots. Transmission of each virus from mixed infection by the common vector, *T. vaporariorum* indicated a much higher transmission efficiency for ToCV than for TICV in both single and mixed infections. This suggests that ToCV has a higher affinity for association with *T. vaporariorum* than TICV, and may influence the ecology of mixed infections.

WINTERMANTAL, W.M., N.F. MOSQUEDA, A.A. CORTEZ, and A.G. ANCHIETA. 2003. *Beet curly top virus* revisited: Factors contributing to recent severe outbreaks in California. Proc. ASSBT-IIRB, San Antonio, TX. pp 295-302.

Beet curly top virus (BCTV), transmitted by the beet leafhopper (*Circulifer tenellus*) has caused significant problems to irrigated agriculture in the western United States since the late 1800s. Although managed annually through an intensive leafhopper eradication program, BCTV re-emerged in 2001 as a serious threat to agriculture in California's San Joaquin Valley. BCTV infects a broad range of crop hosts including sugarbeet, pepper, tomato, bean, spinach, and cucurbits, as well as numerous weeds. Although many strains of BCTV have been identified over the years, molecular characterization of BCTV in sugarbeet has demonstrated that the virus primarily exists as genetic variants of three strains known as CFH, Worland, and California/Logan. Studies conducted in the early 1990s determined that most sugarbeets were infected with either CFH or Worland strains, but little information exists on strain distribution among weed hosts. Studies involving data collected in California and other states has focused on molecular characterization of BCTV isolated from weed hosts, as well as sugarbeet and other selected crops. ELISA for universal detection of BCTV, as well as PCR using strain specific primers have been used to identify BCTV strains infecting crop and weed hosts from both fields and overwintering grounds of the beet leafhopper. Strain identification coupled with sequence analysis provides insight into variability in virus population structure over broad areas, as well as over time.

WINTERMANTEL, W.M., G.C. WISLER, A.V. KARASEV, and H.-Y. LIU. 2003. <u>Genome organization and sequence of *Tomato chlorosis crinivirus*</u>. Proc. American Soc. For Virology, Davis, CA. p176.

Tomato chlorosis virus (ToCV), a whitefly transmitted crinivirus, causes yellowing, of tomato leaves, premature senescence and reduced fruit set in tomato. The virus is common in the southeastern United States, the US greenhouse tomato industry, Southern Europe and other areas of the world. ToCV can be transmitted efficiently by four different species of whitefly from two genera. This exceptionally broad vector specificity is unique within the genus crinivirus. Double stranded RNA of ToCV was extracted from an isolate originally obtained from Florida, and cDNA clones were constructed and used to obtain the sequence of the genome of this large bipartite virus, known to infect several members of the Solanaceae. The genome organization of ToCV resembles that of *Lettuce infectious yellows virus* (LIYV), the best characterized member of the crinivirus genus (for reference see Klaassen et al., 1995 Virology 208: 99-110). RNA1 is organized into 3 ORFs, and is involved in replication of viral RNA, based on homology to other viral replication factors. RNA 2 is composed of 7 ORFs, encoding a hsp70 homolog, and two proteins involved in encapsidation of viral RNA, referred to as the coat protein (CP) and minor coat protein (CPm). Sequence homology between ToCV and LIYV varies throughout the viral genome. The ORF encoding the minor coat protein of ToCV, which presumably encapsidates the 3' end of virions and may be involved in determining vector specificity, is larger than the LIYV complement by 651 nucleotides, with additional sequence present at the 5' end. Similarly, the ToCV CPm itself is also longer than the LIYV CPm by 217 amino acids. Among criniviruses sequenced, considerable variability exists in the size of some viral proteins. Analysis of these differences with respect to biological function may provide insights into the role crinivirus proteins play in virus infection and transmission.

WISLER, G. C., R.T. LEWELLEN, J.L. SEARS, H.-Y. LIU, J.W. WASSON, and W.M. WINTERMANTEL. 2003. Effect of two soil-borne viruses of sugarbeet and their fungal vector, *Polymyxa betae*, on virus accumulation and plant growth in sugarbeet. Proc. ASSBT-IIRB, San Antonio, TX. pp 877-882.

Soils naturally infested with cultures of aviruliferous *Polymyxa betae* and viruliferous *P. betae* carrying the two sugar beet benyviruses *Beet necrotic yellow vein virus* (BNYVV) and *Beet soil-borne mosaic virus* (BSBMV), alone and in combination, were compared to non-infested soil with regard to their effects on virus content, fresh plant weight, and seedling emergence. Two sugar beet varieties were used: a diploid (*Rzrz*) that carries resistance to rhizomania caused by BNYVV, and a triploid rhizomania-susceptible variety (*rzrzrz*). These studies clearly demonstrated that the Rz resistance gene does not confer resistance to BSBMV. Additionally, *P. betae* alone had a significant negative effect on growth of sugarbeet, and soils infested with *P. betae* containing one or both viruses, tended to have reduced seedling emergence and reduced fresh weight, even when protective fungicides were used. BSBMV titers were significantly higher in single infections than in mixed infections with BNYVV in both rhizomania resistant and susceptible varieties. In contrast, BNYVV titers were very high in single and in mixed infections in the Rhizomania-susceptible variety, but low in the resistant variety. Therefore, in the absence of BNYVV, BSBMV concentrations are high in infected roots, regardless of the resistance genotype. In the presence of BNYVV, however, BSBMV concentrations are low in both resistant and susceptible varieties, with absorbance readings similar to those of plants grown in non-infested soils. It appears that even at low levels, BNYVV either out competes or suppresses BSBMV, and suggests that both viruses target similar cellular processes in the sugarbeet plant.

WISLER, G.C., R.T. LEWELLEN, J.L. SEARS, J.W. WASSON, H.-Y. LIU, and W.M. WINTERMANTEL. 2003. Interactions between *Beet necrotic yellow vein virus* and *Beet soilborne mosaic virus* in sugar beet. Plant Disease 87: 1170-1175.

Soils naturally infested with cultures of aviruliferous *Polymyxa betae* and viruliferous *P.betae* carrying two sugar beet benyviruses, *Beet necrotic yellow vein virus* (BNYVV) and *Beet soil-borne mosaic virus* (BSBMV), alone and in combination, were compared with noninfested soil for their effects on seedling emergence, plant fresh weight, and virus content as measured by enzyme-linked immunosorbent assay (ELISA). Studies examined sugar beet with and without resistance to the disease rhizomania, caused by BNYVV. The *Rz* gene, conferring resistance to BNYVV, did not confer resistance to BSBMV, BSBMV ELISA values were significantly higher in single infections than in mixed infections with BNYVV, in both the rhizomania-resistant and –susceptible cultivars. In contract, ELISA values of BNYVV were high (8 to 14 times the healthy mean) in single and mixed infections in the rhizomania-susceptible cultivar, but were low (approximately three times the healthy mean) in the rhizomania-resistant cultivar. Results indicate BNYVV may suppress BSBMV in mixed infections, even in rhizomania-resistant cultivars in which ELISA values for BNYVV are extremely low. Soils infested with *P.betae*, and with one or both viruses, showed significantly reduced fresh weight of seedlings, and aviruliferous *P.betae* significantly decreased sugar beet growth in assays.

YU, M.H. 2003. <u>Developing sugarbeet with resistance to *Meloidogyne* spp.</u> p. 163. *In* Apstr. Intl. Congr. Genet. XIX, July 6-11, 2003, Melborune, Australia.

Root –knot nematodes (*Meloidogyne* spp.) are important sugarbeet (*Beta vulgaris* L.) pathogens that are difficult to control. Host-plant resistance was discovered from rare strains of the wild beet, *B. vulgaris* ssp. *maritima*. The resistance is effective against multiple species and races of nematode belonging to the genus *Meloidogyne*, based on J2 inoculation tests. Incorporation of resistance to root-knot nematode into sugarbeet was carried out through hybridization and back-crossing to sugarbeet in the greenhouse. Selection against annual bolting, disease susceptibility, and root morphology was done from field plantings. The intensity of sprangled root structures and easy bolting habits decreased with selection pressure and as the number of breeding generations progressed. Promising sugarbeet plants with stable resistance transmission and improved taproot conformation eventually developed. Two series of root-knot nematode resistant sugarbeet genotypes, Mi-1 and M66, were generated. From these sources several *Beta* germplasm lines with resistance to *Meloidogyne* spp. have been developed and released.

YU, M.H. 2003. <u>Development of root-knot nematode-resistant sugarbeet.</u> Proc. IIRB-ASSBT Congr. 1: 763-765.

Sugarbeet, *Beta vulgaris*, is a favored host of *Meloidogyne* spp. Host-plant resistance to multiple species of root-knot nematodes was not found in the cultivated sugarbeet but was identified from wild *maritima* beets. The resistance has been introgressed into sugarbeet genotypes. Several breeding populations were planted in heavily infested field plots. Preliminary evaluations indicated that about 77% of plans in resistant families and 44% in backcrossed populations, produced healthy roots while the rest were with gall symptoms. In comparison, none of the susceptible control plants were free from galling; one-third of them died. Positive results were demonstrated by the improved taproot conformation and root weights. A phosphoglucomutase (PGM) isozyme marker for Mi-1 *Beta* and cleaved amplified polymorphic sequence (CAPS) marker for M66 *Beta* were recently identified. The use of marker-assisted selections may facilitate sugarbeet root-knot nematode resistance breeding. Additional improvements on the breeding materials are needed to develop an elite sugarbeet cultivar.

YU, M.H. and R.T. LEWELLEN. 2004. <u>Registration of Root-knot Nematode-Resistant Sugarbeet Germplasm M6-2.</u> Crop Sci. 44: In press.

Sugarbeet (*Beta* vulgaris L.) germplasm M6-2 (Reg. no. GP ..., PI632234) was developed by the USDA-ARS, Salinas, CA, in cooperation with the California Beet Growers Association, Ltd., Stockton, CA, and released in December 2002. M6-2 is highly resistant, if not immune, to root-knot nematode (*Meloidogyne* spp.)

M6-2 was produced by inter-pollinating more than 30 plans selected from the fifth backcross generation progeny of hybrids between M66 (PI 586688; Yu, 1996) and cultivated sugarbeet lines, including C37 (PI 590715; Lewellen et al., 1985) and C78 (PI 593671; Lewellen, 1997). F_1BC_5 plants with root-knot resistance were intercrossed. Nematode resistant F_2BC_5 plants were individually test crossed to a susceptible line. F_2 plants that performed well in test crosses and

appeared to be homozygous for resistance were intercrossed to produce M6-2. M6-2 is a multigerm, biennial, self-incompatible germplasm that is heterogeneous for plant type and hypocotyl color. Approximately 25% of the seedlings have green hypocotyls. Root size and root conformation are not as uniform as the recurrent parents. Due to its wild beet ancestry, roots of M6-2 are often sprangled.

The M6-2 germplasm is resistant to multiple species of root-knot nematode, including *M. incognita* (Kofoid and White) Chitwood, *M. javanica* (Treub) Chitwood, *M. arenaria* (Neal) Chitwood, *M. hapla* Chitwood, *M. chitwoodi* Golden et al., and *M. fallax* Karssen, based on J2 larval inoculation studies in the greenhouse and monoxenic *M. incognita* and *M. javanica* infested field trials (Yu et al., 1999; Yu and Roberts, 2002). The level of resistance to root-knot nematode in M6-2 and M6-1 (PI 613165; Yu, 2001), a first generation backcross progeny of M66, appear to be similar. However, M6-1 is a self-compatible line with green hypocotyls, and taproots tend to be more sprangled than roots of M6-2.

Breeder seed will be maintained by the USDA-ARS and provided to sugarbeet breeders and researchers in small quantities upon written request. Recipients of seed are requested to make appropriate recognition of the source if M6-2 contributes to the development of a new population, parental line, cultivar, or hybrid. U.S. Plant Variety Protection for M6-2 will not be applied for.

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Evaluation of the effect of synergism between BNYVV and BSBMV on resistance to these viruses in sugarbeet

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Introduction:

Rhizomania is now present in all areas of the United States where sugarbeet is grown (Wintermantel et al., 2003). This disease is caused by *Beet necrotic yellow vein virus* (BNYVV), a benyvirus transmitted by the soil-borne fungus *Polymyxa betae*. All BNYVV isolates from soils in the U.S. are identical, based on: (1) studies of the responses of susceptible host plants; (2) serological relatedness of the coat protein and several nonstructural proteins; (3) the number and size of the RNAs in each isolate; (4) and the relationship of each RNA on a molecular level compared to a European isolate of BNYVV. This American isolate was probably introduced from Europe, where multiple isolates exist, and has since spread throughout North America. *Beet soil-borne mosaic virus* (BSBMV) is often present in beet plants that are also infected with BNYVV. All BSBMV isolates are serologically identical to one another, but differ in host response and the number and size of viral RNAs. This pattern is indicative of a virus which originated and has evolved in North America. None of the BSBMV isolates cause the root proliferation characteristic of Rhizomania disease and BNYVV infection, but our studies indicate that BSBMV isolates do reduce growth of beets (Wisler et al., 2003).

Several control measures have been established for rhizomania. These have been developed over several years of research by pathologists and breeders, and include: (i) avoidance of infested fields by testing soil for the presence of *Beet necrotic yellow vein virus* (BNYVV) prior to planting, (ii) early planting into cool soils, (iii) soil fumigation where allowed, and (iv) use of resistant cultivars. These measures apply to all soil-borne fungus-transmitted viruses of sugarbeet, including BNYVV, *Beet soil-borne mosaic virus* (BSBMV), and *Beet soil borne virus* (BSBV). Viruliferous *P. betae* (*P. betae* containing virus) remains in soil after harvest and can survive for many years. It is important, therefore, to decrease levels of virus inoculum in the soil by whatever means possible. The most cost-effective and successful control measure for growing beets in infested soil is the use of resistant varieties. Many sugarbeet cultivars have now been bred with varying degrees of resistance to rhizomania. Resistant varieties are not immune to BNYVV, but do reduce virus accumulation and disease severity. Current resistant varieties now yield nearly as well as non-resistant varieties in the absence of rhizomania disease pressure.

Over the past several years, both sugar and tonnage were decreased in Great Plains beet growing regions. Several causes have been attributed to this problem including *Cercospora* leafspot, *Rhizoctonia*, root aphids, root maggots, rhizomania (caused by BNYVV) and BSBMV, to name a few.

Although rhizomania was initially blamed for the low yields, repeated tests from labs at the University of Nebraska in Scottsbluff were negative for BNYVV. Results from previous studies by our laboratory in Salinas suggest that BSBMV, in particular, may be important in the yield losses. One of the most significant findings from our initial studies on the yield decline experienced by Great Plains region sugarbeet producers was that 24 of 27 soils tested, showing the decline in sugarbeet production were infested with either BSBMV, BSBV, or both. Only 2 of the soil samples were positive for BNYVV, and one of these was a soil which had been submitted as a rhizomania positive control. Although the effects of Rhizomania were well known on sugarbeet, much less was known about the effects of BSBMV or BSBV on beets. It was suspected that these viruses, either alone or in combination, contributed to a yield loss in sugarbeet. Studies conducted in our greenhouses in Salinas examined soils infested with BNYVV, BSBMV, both viruses, and virus free *P. betae*, as well as virus and vector-free soil. The results of these studies identified two problems that significantly reduced sugarbeet growth, compared with non-inoculated control plants. Beets grown in soil infested with both BSBMV and BNYVV were sometimes stunted much more severely than those grown in soil infested with either virus alone. In addition, *P. betae*, with or without virus had a significant effect on beet growth. Studies on virus concentration in infected plants demonstrated that BNYVV is more competitive in sugarbeet than BSBMV, suppressing BSBMV concentrations in infected tissue during mixed infection in greenhouse tests (Wisler et al., 2003).

Compared with BNYVV, much less is known about the effects and importance of other *P. betae* vectored viruses in the rhizomania disease syndrome. Knowledge that has been generated on BNYVV, however, can often be applied to the study of BSBMV. Our greenhouse studies in Salinas have shown that BSBMV can have a significant effect on growth of sugarbeet, whether alone or in combination with BNYVV. Recently completed research by our lab demonstrated that BNYVV and BSBMV, as natural mixed infections from infested soil, can have a significantly greater detrimental effect on beet growth than either virus alone (Wintermantel et al., 2001; Wisler et al., 2003). This recent finding has led to a number of additional challenges. We need to determine what effect non-BNYVV furoviruses (now collectively called *Benyviruses* for *Beet necrotic yellow vein virus*; Torrance and Mayo, 1997) have on field production of sugarbeet. Secondly, can we identify sources of resistance to BSBMV. We need to concentrate our efforts on: (1) characterizing the nature of the interactions between BNYVV and BSBMV, and (2) take advantage of the decreased severity of BSBMV (in single infections) to determine what viral genetic differences are responsible for converting a relatively mild virus (BSBMV), into a highly damaging virus (BNYVV). This may ultimately lead to an opportunity to develop targeted strategies for preventing BNYVV symptom expression and possibly replication in sugarbeet.

The High Plains production region has seen increasing numbers of fields become infested with not only BNYVV, but also BSBMV in recent years, confirmed by a number of independent sugarbeet research laboratories, including the USDA-ARS Virology Lab in Salinas. The presence of both soil-borne viruses in the same fields will likely lead to virus interactions in sugarbeet plants and the synergism described above that can result in further yield decreases. Our research is working toward determining not only how these interactions affect sugarbeet, but more importantly, toward identifying beet varieties with better performance under conditions of mixed infection.

Project Accomplishments (over life of the project):

1. The TAS-ELISA test modified for BNYVV in our studies gave no background cross-reactions with other soil-borne viruses of sugarbeet, in particular, isolates of BSBMV. One isolate each of BSBMV from Texas and Minnesota gave reactions equivalent to those of healthy sugar beet roots and healthy leaf tissues of *B. macrocarpa*. In addition, serial dilution studies with the BNYVV antiserum demonstrated that variation in BNYVV content among resistant and susceptible sugarbeet varieties can be detected. The BNYVV antiserum developed in Salinas has become the standard for detection of BNYVV and has been licensed to Agdia for commercial availability.

2. ELISA tests were used to determine levels of BNYVV among eight sugarbeet varieties. Differences in absorbance (A405 nm) values closely corresponded to a gene dosage effect, specifically to the frequency of the Rz allele that conditions resistance to BNYVV. This demonstrated differential expression of Rz resistance alleles. Differences in BNYVV levels were observed among harvest dates, with progressively lower absorbance values measured as the season progressed. This pattern held true for all cultivars.

3. Absorbance values were significantly positively correlated with rhizomania disease index scores and negatively correlated with individual root weight, plot root weight and sugar yield. These results are important in plant breeding, variety development, and cultivar evaluation. They show that the breeder or agronomist can be fairly confident of measuring varietal reactions to rhizomania by either scoring or weighing field grown material. Root weights and visual scoring are usually made more easily in a breeding or testing program than absorbance measurements from ELISA tests. This information is useful in resistance breeding and evaluation programs and for the sugar industry in consideration of cultivar choice, inoculum production and rotations for future cropping.

4. Eight sugarbeet cultivars, that range in reaction to rhizomania from uniformly susceptible to highly resistant, were compared for levels of BSBMV. Infections were established by growth in soil infested with viruliferous *Polymyxa betae*. All cultivars were highly susceptible to BSBMV, with absorbance readings ranging from 8 to 12 times the healthy root mean. In current studies, when mixed infections of BNYVV and BSBMV were compared to single infections in both a susceptible and resistant sugarbeet line, the reactions, as measured by root symptoms and individual beet weight were significantly more severe than for each virus alone. This was true regardless of whether the seedlings were initially grown in soil infested with either BNYVV or BSBMV. Thus, resistance to BNYVV does not confer resistance to BSBMV, nor does BSBMV infection moderate the effects of BNYVV.

5. BSBMV levels were significantly decreased by the presence of BNYVV in both BNYVV-resistant and susceptible varieties grown in soil infested with both viruses compared with singly infested soils. In contrast, BNYVV levels were either unaffected or increased in the presence of BSBMV. This demonstrated that interactions between soil-borne viruses significantly affect virus accumulation and disease severity in sugarbeet.

6. *Trichoderma virens*, a biocontrol fungus, was tested for its ability to suppress *P. betae*, the vector of BNYVV, and subsequently reduce BNYVV transmission to sugarbeet. Results demonstrated that any reduction in *P. betae* populations was not sufficient to prevent infection or affect virus accumulation in sugarbeet.

7. A thorough analysis of broad sugarbeet germplasm sources conducted over a two year period did not identify any significant sources of resistance to BSBMV. Some sources appeared to

perform slightly better, based on suppression of BSBMV levels as measured by ELISA, but none resulted in BSBMV suppression significantly different from fully susceptible controls and would not be useful in a selection program.

Objectives for 2003:

1. Differentiate variety reactions to BSBMV among both representative commercial hybrids, sugarbeet breeding lines, and germplasm resources to identify potential sources of resistance to BSBMV and other soil-borne viruses of sugarbeet.

2. Evaluate representative sugarbeet varieties adapted for the High Plains region for yield effects and relative concentrations of virus following growth in soil infested with BNYVV alone, or soil infested with both BNYVV and BSBMV to determine performance under pressure from virus synergism.

3. Examine the effect of BSBMV alone on sugarbeet growth and virus concentration under field conditions through studies conducted in isolation plots.

4. Assemble small clones generated during sequencing the genome of the Texas 7 isolate of BSBMV (Lee and Rush, 2001) into full-length infectious clones that can be used in future studies to determine why BSBMV does not elicit the hairy root symptoms characteristic of BNYVV (rhizomania) on sugarbeet roots. The information gained may ultimately lead to new control strategies for BNYVV and other soil-borne viruses.

Results from the current funding period (recent accomplishments):

Year 1 results: Objectives 1 and 3 were addressed in studies conducted in microplots. R.T. Lewellen provided sugarbeet seed from the USDA-ARS germplasm collection in Salinas for these studies. Small, contained research plots were constructed at the USDA-ARS Research Station in Salinas, containing *P. betae* and BSBMV, for the specific purpose of identifying resistance to BSBMV in sugarbeet germplasm. Separate plots were developed and provided with virus-free soil for use as controls. These plots were tested in the spring/summer of 2002 for disease incidence and found to produce consistent, uniform BSBMV infections. Resistance tests were conducted in the summer and fall of 2002 with 8 varieties of segregating germplasm tested. Seed was grown under field conditions in plots infested with *P. betae* and BSBMV, or non-infested soil for 2 months. At the end of this period, beets were assayed individually for BSBMV accumulation using ELISA with BSBMV specific antiserum. BSBMV infections developed well in test plots, while virus-free plots did not have any incidence of BSMBV. Analysis of 2002 tests suggested BSBMV resistance might be present in some germplasm sources, but further testing was necessary. Varieties of European origin exhibited the least resistance (Beta4430 and Beta6600). This was not surprising, as incidental selection for BSBMV resistance would not have occurred in Europe, since the virus is not present there. Most other lines tested had lower levels of virus accumulation and lower percents infection, suggesting BSBMV resistance may be present in a number of these sources. Line 9933, which performed better than all other lines, was developed in Salinas, but incorporated germplasm selected over time in Colorado, where BSBMV is prevalent. Sugarbeet varieties being screened were

segregating lines, such that some plants within a variety may be resistant while others are not, even from the same seed lot.

Year 2 results: Based on the promise shown in some of the material tested in 2002, we tested this material further in 2003, using similar but more stringent methods. As in the previous year, plants were grown in microplots infested with BSBMV, with planting in late May when soil was warm and *P. betae* would be active. After 2 months, plants were harvested and roots tested for BSBMV levels by ELISA as in the previous year. Initial testing of plants from microplots suggested similar results to those obtained in 2002. A total of 28 plants from 6 varieties had low ELISA readings compared with susceptible controls. The majority of low readings were in 3 varieties, 9933 (10 plants), which also looked promising in 2002, FC1030 (7 plants), and Y169 (6 plants). Low levels of virus were also found in a few plants of P207 (3 plants), Y275 and R221 (1 plant each). Plants with low levels of BSBMV were placed in 6" clay pots and grown for an additional 6 weeks in the greenhouse. During the 6 weeks in the greenhouse, sugarbeet plants would develop new rootlets, and if plants were not resistant the new rootlets would have levels of virus comparable to susceptible varieties. If truly resistant, virus levels should remain low, similar to those in healthy control plants. This more stringent analysis allowed us to determine if the low levels of BSBMV observed in the microplots resulted from true resistance to BSBMV or if it resulted from cyclical variation in virus concentration within the plants, a phenomenon that occurs regularly with plant virus infections over time.

After 6 weeks, roots were again tested by ELISA. All plants re-grown in the greenhouse had high levels of BSBMV (over 2X background) **(Table 1)**. Some even had foliar symptoms. Based on these results we concluded that although there initially appeared to be potential for resistance, particularly in line 9933, none of the material tested exhibited even moderate levels of resistance under stringent selection pressure and will likely not have much potential for use in breeding and selection for resistance to BSBMV. It is possible that 9933 and perhaps FC1030 may have a slightly greater ability to limit virus accumulation under field conditions, as suggested by results from growth in the microplots. The higher pressure resulting from passage through the greenhouse screen, however, was far too strong and all plants had high virus concentrations after the 6 week greenhouse passage. Both lines 9933 and FC1030 can be traced to the Great Western breeding line, GW359, however they have undergone separate breeding paths over the last 50 years. GW359 was derived from selections made in the Great Plains, where BSBMV is probably native, thus explaining the slightly better performance of the two lines derived from GW359. At this point we have examined all potential sources of resistance to BSBMV available, and regrettably, it does not appear that any lines have sufficient resistance to warrant further testing and selection. The levels of possible resistance observed with FC1030, Y169 and 9933 are not sufficient to allow for germplasm selection.

Studies on the effect of mixed infection on performance of resistant varieties (Objective 2) was delayed, due to the need to first identify sources of resistance to BSBMV. Since currently available germplasm sources are not resistant to BSBMV, it will not be possible to select sources with resistance to both viruses from naturally occurring sugarbeet germplasm or existing sources of wild germplasm.

Objective 4: Partial clones of BSBMV were provided by Dr. Lawrence Lee, formerly of the Texas Agricultural Experiment Station, Bushland, TX with C.M. Rush. Partial clones are being

assembled into full-length BSBMV RNAs using RT-PCR with a high fidelity DNA polymerase. For areas of the genome where clones were not available, viral RNA is being purified from plant material and used for RT-PCR based cloning. Complete full-length clones of BSBMV RNAs 3 and 4 have been constructed. Large, partial clones of RNAs 1 and 2 (which are much larger) were constructed last year, but obtaining full length clones of RNAs 1 and 2 was more difficult than anticipated, and alternate approaches were necessary. As a result, BSBMV RNA was purified from plant material. Based on the known sequence of BSBMV, RT-PCR primers were designed to amplify full-length BSBMV RNAs using reverse transcriptase and a high fidelity DNA polymerase. The amplified products were subsequently cloned into bacterial plasmid vectors (circular DNA constructs used for DNA cloning and gene expression that allow one "grow" the DNA in bacterial cells) that can be used for production of viral RNA. Sequencing of clones still has not resulted in full length constructs. Sections of the genome are either being "skipped over" by the polymerase during amplification, or the bacteria are "discarding" sections of the virus. This is not uncommon with some viral sequences, but could not have been anticipated. We are continuing our efforts to overcome this problem. This is the last year for this project, and it is our hope that these problems can be resolved in short order and full-length infectious clones obtained.

Supplemental: Studies were conducted to determine if biocontrol agents, such as *Trichoderma virens*, could reduce populations of *P. betae* sufficiently to reduce infection or impact of BNYVV on sugarbeet. Studies were conducted collaboratively with L. Hanson (USDA-ARS, Ft. Collins, CO) who provided three *T. virens* strains that had shown differential activity against other soil-borne fungi. The G-6 strain was shown to be effective against Rhizoctonia, the G-4 strain was effective against *Pythium ultimum*, and the LH-2 strain was generally effective in alkaline soils, based on studies conducted previously by Dr. Hanson. To our knowledge no previous studies have been attempted for control of *P. betae* with *T. virens*. Experiments were designed as follows, and replicated a total of 6 times. Cumulative results are presented in **Table 2**, below. Soil was obtained from a field with severe rhizomania infestation (Spence field rhizomania test plot, USDA-ARS-Salinas) and mixed with equal parts sterile builders' sand. Controls consisted of autoclaved soil mixed with sterile sand. Soil mix was placed in 3" diameter foam cups with a drainage hole in the bottom. Susceptible sugarbeet seed (variety Beta6600) was planted into the cups. *T. virens* was added directly over seed at planting at a ratio of approximately 1/8 teaspoon per cup of soil. Five weeks after planting sugarbeet plants were harvested, soil washed from roots, and weight determined. Roots were tested for BNYVV using standard ELISA procedures. Although *T. virens* targets *P. betae* rather than BNYVV, results, presented in Table 2 indicate performance of each *T. virens* strain in reducing BNYVV titers and potential effects on diminishing the reduction in beet weight associated with BNYVV infection. No significant differences in weight or virus titer were observed between any of *T. virens* treatments and untreated controls. Sterile soil (Control without P. betae and BNYVV) resulted in beets twice as large as those in any of the diseased treatments, with or without *T. virens*.

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Table 1. BSBMV accumulation among individual sugarbeet plants evaluated in summer 2003 in field microplots, followed by passage for 6 weeks in fresh soil in the greenhouse.

Breeding Line	ELISA (A405)[1]
FC1030 A	1.238
FC1030 B	0.345 (stunted[2])
FC1030 C	0.617
FC1030 D	0.885
FC1030 E	0.613
FC1030 F	0.694
FC1030 G	0.295 (stunted)
9933 A	1.450
9933 B	0.614
9933 C	0.694
9933 D	0.500
9933 E	1.093
9933 F	0.727
9933 G	0.138 (stunted)
9933 H	0.828
9933 I	0.739
9933 J	0.569
Y169 A	0.650
Y169 B	0.628
Y169 C	0.648
Y169 D	0.648
Y169 E	0.570
Y169 F	0.116 (stunted)
P207 A	0.741
P207 B	1.405
P207 C	0.527
Y275 A	0.596
R221 A	0.742
BSBMV infected B. macrocarpa	2.005
BNYVV infected B. macrocarpa	0.127
Healthy B. macrocarpa	0.117
Healthy B. vulgaris	0.119
Blank	0.116

1. Mean absorbance at 405nm as measured by enzyme-linked immunosorbent assay (ELISA) using antiserum specific for BSBMV.
2. Stunted plants refer to plants that did not grow much at all once placed in the greenhouse. Virus concentrations in these plants were uniformly low, probably since new root growth never developed, preventing renewed virus accumulation.

Table 2. Effect of *Trichoderma virens* on infection and severity of BNYVV in susceptible sugarbeet varieties.

Treatment	Mean plant weight (g)[1]	Abs. (A405)[2]	# Plants
Autoclaved Soil	0.422	0.107	442
Diseased Soil 1	0.199	0.382	182
Diseased Soil 2	0.199	0.425	202
Diseased Soil 3	0.186	0.412	135
T. virens G6	0.182	0.434	168
T. virens LH2	0.184	0.453	207
T. virens G4	0.162	0.424	207

[1] Weight and Absorbance values are mean values from 6 repetitions of each treatment. The number of plants tested is listed in the right column.

[2] Absorbance measured by ELISA at 405 nm using antiserum specific for BNYVV and standard ELISA techniques (Wisler et al., 2003). All absorbance values more than 3 times the value for autoclaved soil (healthy control) are considered infected.

REFERENCES:

Lee, L. Telford, E.B., Batten, J.S, Schlothof, K.-B.G., and Rush, C.M. 2001. Complete nucleotide sequence and genome organization of Beet soilborne mosaic virus, a proposed member of the genus Benyvirus. *Arch. Virol.* 146:2443-2453.

Torrance, L. and Mayo, M. S. 1997. Proposed reclassification of Furoviruses. *Arch. Virol.* 142:435-439.

Wintermantel, W.M., Wisler, G.C., Lewellen, R.T., Liu, H.-Y., and Sears, J. 2001. Interactions between BNYVV and BSBMV in sugarbeet affect virus titer and beet development. *Phytopathology* 91: S150.

Wintermantel, W.M., Crook, T., and Fogg, R. 2003. First report of rhizomania disease of sugar beet caused by *Beet necrotic yellow vein virus* in the Great Lakes production region. *Plant Disease* 87(2): 201.

Wisler, G.C, Lewellen, R.T., Sears, J.L., Wasson, J., Liu, H.-Y. and Wintermantel, W.M. 2003. Interactions between *Beet necrotic yellow vein virus* and *Beet soilborne mosaic virus* in sugar beet. *Plant Disease* 87: 1170-1175.

STUDY OF NEW PATHOTYPES OF RHIZOMANIA IN THE UNITED STATES

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SUMMARY

Rhizomania is an important disease of sugar beet. This disease is caused by *Beet necrotic yellow vein virus* (BNYVV). Partially resistant sugar beet cultivars based upon single dominant genes have been developed against this devastating disease. In 2002 and 2003 several sugar beet fields with a BNYVV-resistant cultivar in the Imperial Valley of California were observed with severe rhizomania symptoms, suggesting that resistance had been compromised. Standard soil baiting with sugar beet plants followed by ELISA tests were used to diagnose virus occurrence and reaction. Resistant varieties grown in regular BNYVV-infested soil remained resistant. In contrast, when grown in Imperial Valley BNYVV-infested soil all resistant varieties tested susceptible according to elevated ELISA values. Eight different BNYVV isolates have been isolated from Imperial Valley soil (IV-BNYVV) by single local lesion isolation. IV-BNYVV isolates did not contain RNA-5 as determined by RT-PCR. In single-strand conformation polymorphism analyses all the isolates the banding patterns were identical to A-type and different from P-type. From our preliminary results indicate the resistance-breaking BNYVV isolates evolved from existing A-type.

INTRODUCTION

Rhizomania is one of the most economically important diseases of sugar beet and is widely distributed in most sugar beet growing areas worldwide. This disease is caused by *Beet necrotic yellow vein virus* (BNYVV) (Tamada and Baba, 1973; Tamada, 1975) and vectored by the soil-borne fungus *Polymyxa betae* Keskin (Fujusawa and Sugimoto, 1976). Most sugar beet production areas are dependent upon resistant sugar beet cultivars to control this devastating disease. In 2002-2003, several sugar beet fields with a BNYVV-resistant cultivar in the Imperial Valley of California were observed with severe rhizomania symptoms, suggesting that resistance had been compromised.

There are three major strain groups of BNYVV that have been reported (Kruse et al., 1994; Koenig et al., 1995; Koenig and Lennefors, 2000). Pathotype A was found in most countries. Pathotype B was observed in Germany and the upper Rhine Valley in France. Pathotype P seems to be more aggressive has so far been found in the region around the French town of Pithiviers and East Anglia in the UK which contained a fifth RNA. Other more infective strains of BNYVV have been found in Kazakhstan, China, and Japan. Experimental evidence from Europe, Japan, and the UK has shown that this strain can infect partially resistant beet varieties. The sequences of RNA 5 of the European and the Japanese sources are related, but differ by 37 point mutations and 20 insertion/deletion mutations (Koenig et al., 1997). The different BNYVV pathtypes could be distinguished by means of Restriction fragment length polymorphism (RFLP) and single strand conformation polymorphism (SSCP) analysis of RT-PCR products (Kruse,

et al., 1994; Koenig et al., 1995). SSCP is a powerful tool for the detection of genome differences. When the plus and minus strands of a double stranded DNA, usually a PCR product, are separated by heat treatment they attain metastable sequence-specific folded structures. The particular electrophoretic mobilities can be detected in non-denaturing polyacrylamide gels. Even single nucleotide exchanges have been reported to be detectable.

In this research, the resistance-breaking BNYVV isolates in Imperial Valley, California were isolated and the host ranges and the pathotype of these isolates were determined.

MATERIALS AND METHODS

Soil test: Soil samples from Imperial Valley, California were mixed in equal parts with autoclaved sand to facilitate ease of root removal at harvest. Greenhouse benches were washed in 10% sodium hypochlorite prior to use. Pots were new 280 ml Styrofoam cups with holes punched in the bottom for drainage and were placed in sterilized plastic saucers spaced on greenhouse benches to avoid contamination by splashing water between cups. After cups were filled with the appropriate soil sample, they were drenched with fungicides [Apron 25W (0.2 g^{-1}) and Terraclor 75W (0.25 g^{-1})] to help control damping off and root rotting caused by *Pythium* spp. and *Rhizoctonia* spp. Approximately 100 sugar beet seeds were layered on top of each pot. Seeds within each pot were covered with sand to a depth of about 1 cm, and the pots were watered with gentle misting as needed. Following misting, water was added to the saucers directly as needed to prevent wilting. Greenhouses were maintained at 15-24 C without supplement light. Samples were harvested starting 4 weeks post emergence of seedlings and continue for 3 weeks. The sugar beet varieties used were rhizomania-resistant varieties: Beta 4430R (Rzrz), KWS Angelina (Rzrz+Rz2rz2) and breeding line 1927-4H5 (Rzrz+WB) and rhizomania-susceptible variety Beta 6600 (rzrz). The soil samples used were sterilized soil, standard BNYVV-infected soil, and Imperial Valley soil. Roots from these pots were harvested and tested for BNYVV.

Enzyme-linked immunosorbent assay (ELISA): The double antibody sandwich ELISA was used. Purified IgG made to BNYVV (1mg/ml) was used to coat microtiter plates at a 1/1000 dilution, and plates were incubated at 37 C for 1 hour. After washing 3 times with PBS-Tween (3 minutes each), 100µl of root extract was added to each well, and allowed to incubate overnight at 4C. Plates were again washed with PBS-Tween. Alkaline phosphatase-conjugated anti-BNYVV IgG was added to wells (100 µl of 1/1000 dilution). Plates were incubated for 1 hour at 37C, and then washed with PBS-Tween. Alkaline phosphatase substrate (Sigma Chemical, St. Louis, MO) were used at a ratio of 5 mg/8.3 ml of substrate buffer.

Roots from each Styrofoam cup were washed free of remaining soil. Root tissue (0.2 g from each root mass) was taken from each cup and added to 2 ml of extraction buffer (0.05 M Phosphate-buffered saline, pH 7.2 with 0.5% Tween 20 and 0.4% dry milk powder). Root tissues were homogenized in sample extraction bags with a hand-held roller press (Agdia, Inc.). Expressed sap (100 µl per well) was added to each of two wells of a microtiter plate. Each plate also contained paired wells with (i) sample buffer only, (ii) BNYVV-infected beet roots, (iii) healthy beet roots, (v) leaf tissue from

BNYVV-systemically infected *B. macrocarpa* (*B. vulgaris* spp. *maritima* var. *macrocarpa*) plants, (vi) leaf tissue from healthy *B. macrocarpa*. Absorbance readings (A_{405nm}) were made at 1 hr after add substrate with a Bio-Tek EL312e microplate reader (Winooski, VT). ELISA value of the test samples absorbance at A_{405nm} 3 times greater than the healthy mean was considered to be positive.

Virus isolates. The root samples from Imperial Valley soil testing were ground 1:5 (wt/vol) in 0.1 M phosphate buffer, pH 7.0, with autoclaved mortars and pestles. A small amount of Celite was added and *Chenopodium quinoa* Will. Plants were inoculated with this suspension by means of a cotton swab. Each single local lesion was subinoculated to *C. quinoa*. Local lesions were freeze dried for virus source.

Host range. Selected host plant species used for inoculations were held in the dark for 16-24 hr prior to inoculation. Test plants were mechanically inoculated as above. Inoculated plants were maintained for symptom development in a greenhouse under natural lighting with a temperature ranged of 26 to 32 C. The symptoms were assessed weekly.

Reverse transcription-polymerase chain reaction (RT-PCR): Viral RNA extracted from purified virion preparations by using the RNeasy Mini Kit (QIAGEN Inc., Valencia, CA) according to the manufacturer's instructions, was denatured by heating at 95 C for 10 min and annealed with an antisense oligonucleotide primer specific for BNYVV-RNA 5. First strand cDNA and PCR procedures were described previously (Liu, et al. 2003).

Single-strand conformation polymorphism analysis (SSCP): RT-PCR products using 20-mer oligonucleotide primers designed to amplify BNYVV RNSs 1 and 2 were denatured by heating for 5 min at 70 C in an equal volume of formamide containing 20 mM-EDTA. 0.1% bromophenol blue and 0.1% xylene cyanol and immediately cooled on ice (Koenig, et al., 1995). Samples were analyzed by electrophoresis in a 10 % polyacrylamide/ bisacrylamide gel (29:1). The 0.8 mm-thick gel was run at 200 V of constant voltage for 6 h at 4 C in a mini slab unit (idea Scientific, Corvallis, OR) with 1X TAE (40 mM Tris-acetate and 2mM EDTA, pH 8.0). After electrophoresis the gels were silver-stained as described by Bassam et al. (1991).

RESULTS

Soil and ELISA tests: Standard soil baiting with sugar beet seedlings followed by enzyme-linked immunosorbent assay (ELISA) were conducted. Resistant varieties grown in regular BNYVV-infested (Spence field) soil remained resistant. In contrast, when grown in Imperial Valley BNYVV-infested soil all resistant varieties tested susceptible according to elevated ELISA values (Table 1). From the soil testing, results suggested that resistance had been compromised in Imperial Valley.

TABLE 1: ELISA TEST OF SUGAR BEET GROWN IN IMPERIAL VALLEY SOIL COMPARED TO STANDARD BNYVV SOIL

Beet Variety	Spence field soil	Imperial Valley soil	Sterilized soil
Beta 6600 (rzrz)	5.1 (+) ab	7.6 (+) a	1.0 (-) d
Beta 4430 R (Rzrz)	2.1 (-) cd	5.4 (+) ab	1.0 (-) d
KWS Angelina (Rzrz + Rz2rz2)	1.2 (-) d	4.0 (+) bc	1.1 (-) d
USDA 1927-4H5 (Rzrz + WB)	2.2 (-) cd	6.2 (+) ab	1.0 (-) d

+ or − based upon > 3X healthy check where healthy check = 1.0
Duncans for all 12 interaction means. Means with a letter in common are not significantly different at the 5% level.

Host range test: After soil baiting tests, infected roots were mechanical inoculated to the local lesion host *C. quinoa* plants. From each single local lesion isolate we did host range tests. Based on the host reaction we have isolated eight different BNYVV isolates from Imperial Valley soil (IV-BNYVV) (Table 2).

TABLE 2. THE RESPONSE OF IMPERIAL VALLEY BNYVV ISOLATES ON DIFFERENT HOSTS

HOST	Imperial Valley BNYVV Isolate							
	1	2	3	4	5	6	7	8
Beta macrocarpa	S	S	S	S	S	S	S	S
B. vulgaris (Beta 6600)	-	S	S	S	S	S	-	-
B. vulgaris (Beta 4430R)	-	S	CLL	S	CLL	S	CR	CR
B. vulgaris (KWS Angelina)	CR	S	CLL	CLL	CLL	CLL	CR	CR
B. vulgaris (1927-4H5)	-	CLL	CLL	CLL	CLL	CLL	CR	CR
Chenopodium amaranticolor	CLL	NLL	NR	CLL	CLL	C/NLL	CLL	CLL
C. capitatum	NLL	-	C/NLL	CLL	CLL	S	-	NLL
C. quinoa	CLL	CLL	CLL	CLL	CLL	CLL	CLL	CLL
Nicotiana benthamiana	-	-	S	-	S	S	-	S
N. clevelandii	-	-	S	S	-	-	-	S
N. glutinosa	-	-	SNLL	-	NLL	-	-	-
Spinacia oleracea	-	S	S	S	CLL	S	-	-
Tetragonia expensa	CR	-	CLL	CLL	CLL	CLL	NLL	-

CLL: chlorotic local lesions; C/NLL: chlorotic/necrotic local lesions; CR: chlorotic rings; NLL: necrotic local lesions; NR: necrotic rings; S: systemic infection; SNLL: small necrotic local lesions; -: non-host.

Reverse transcription-polymerase chain reaction (RT-PCR): In order to find out whether IV-BNYVV isolates contain RNA-5, we used BNYVV RNA-5 specific primer pairs and RT-PCR technique. If the samples contained RNA-5 there will be an expected size of fragment (260 base pair) produced. RT-PCR results on a 1.5 % agarose gel are shown in Fig. 1. P-1 and P-2 are known P-types of BNYVV that possess RNA-5 and a band of 260 base pair was formed. A-1 to A-4 are known A-types without RNA-5 and no visible band of 260 base pair area were observed. IV-1 to IV-8 were BNYVV isolates

from the Imperial Valley. The 260 base pair band could not be detected for these isolates. These results indicate that the BNYVV isolates from Imperial Valley did not contain RNA-5.
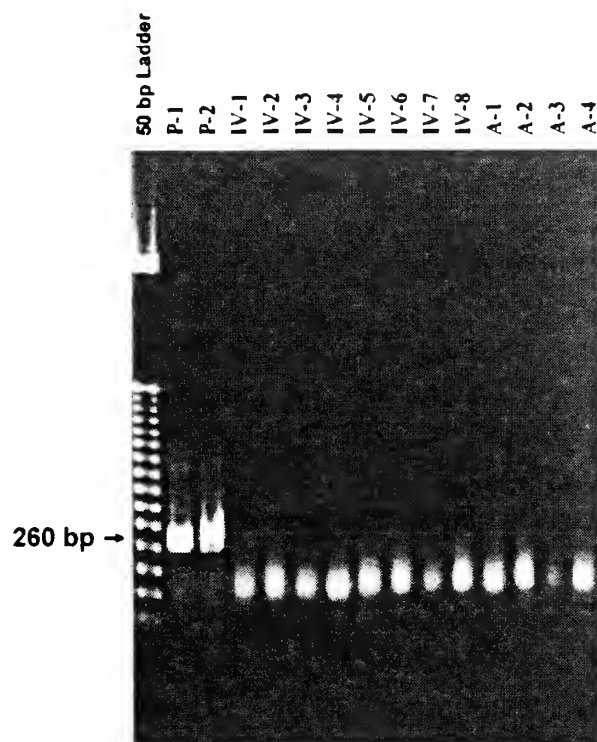
Fig.1. A 1.5% agarose gel showing the products (260 bp) of RT-PCR using BNYVV- RNA 5 specific primer pairs.

Single-strand conformation polymorphism analysis (SSCP): We used SSCP analyses to compare the banding patterns of IV-BNYVV isolates with known P-pathotype and A-pathotype of BNYVV isolates. Samples were analyzed by electrophoresis in a 10 % polyacrylamide/ bisacrylamide (29:1) gel. After electrophoresis the gels were silver-stained. The SSCP results are shown in Fig. 2.
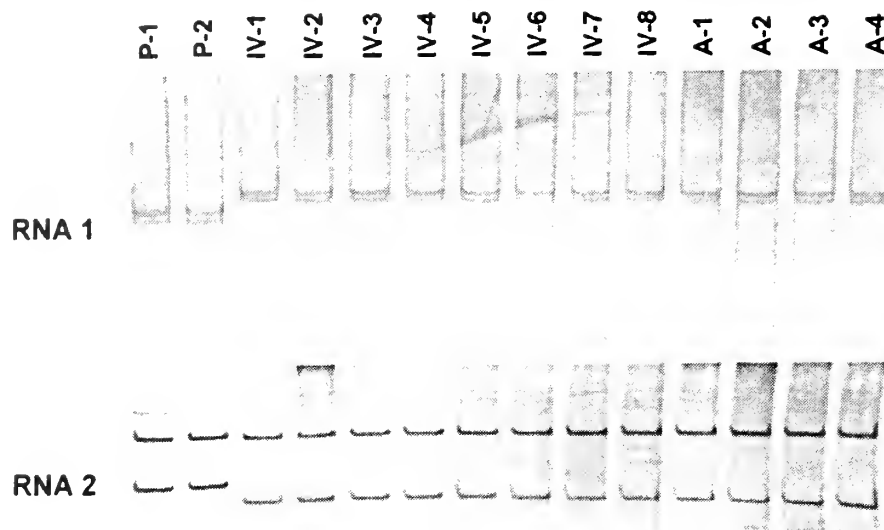
Fig. 2. Single-strand conformation polymorphism analysis patterns given by RT-PCR products for two different regions on BNYVV RNA 1 and RNA 2. The sample arrangements are same as Fig. 1. The IV-BNYVV banding patterns from both RNA 1 and RNA 2 are identical to A-pathotype and different from P-pathotype.

CONCLUSIONS

From our experiment, results indicate that IV-BNYVV isolates do not contain RNA-5 as determined by RT-PCR. In single-strand conformation polymorphism analyses, all of the BNYVV isolates from Imperial Valley had banding patterns from RNA 1 and RNA 2 that were identical to A-type and different from P-type. We concluded that the resistance-breaking BNYVV isolates from Imperial Valley likely had evolved from the original existing A-type.

The emergence of resistance-breaking virus variants is due to genomic variation. There are four types of genomic variation in plant viruses including mutation, recombination with other RNA plant viruses, genome segment reassortment, and acquisition of a range of extra nucleic acid components (Harrison, B. D., 2002). Mutation is the most common cause of viral genomic variation and is a necessary precursor to other types of genomic variation. Among RNA viruses, the typically short replication time, high yields and high mutation rates result in virus cultures consisting of a complex dynamic swarm of mutants. However, most mutants are either not viable or not positively selected. The consensus sequence in such mutants will change in response to a change in environmental conditions, for example, temperature changes or continued use of resistant cultivars.

The large-scale development of resistant cultivars may impose selection pressure and lead to partial or total breakdown of resistance. Consequently, the durability of beet cultivars which are resistant to BNYVV should be assessed, not only to the original A-pathotype but also to those resistant-breaking isolates. Additional sources of resistance with different genetic determinants should also be sought to increase the stability and durability of the resistance.

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To search for additional sources of resistance and specifically to the strains found in the Imperial Valley, an isolated field plot was established at Salinas in 2003. In 2004, a wide array of *Beta vulgaris* germplasm will be evaluated in an attempt to identify high resistance to these new strains of BNYVV. In addition, the industry has established a field plot *in situ* in the Imperial Valley for evaluating host plant resistance to these emerging strains.

REFERENCES

Bassam, B. J., Caetano-Anolles, G., and Gresshoff, P. M. 1991. Fast and sensitive silver staining of DNA in polyacrylamide gels. Anal. Biochem. 196:80-83.

Fujisawa, I. and Sugimoto, T. 1976. Transmission of *Beet necrotic yellow vein virus* by *Polymyxa betae*. Ann. Phytopathol. Soc. Japan. 43:583-586.

Harrison, B. D. 2002. Virus variation in relation to resistance-breaking in plants. Euphytica 124: 181-192.

Koenig, R., and Lennefors, B.-L. 2000. Molecular analyses of European A, B and P type sources of *Beet necrotic yellow vein virus* and detection of the rare P type in Kazakhstan. Arch. Virol 145:1561-1570.

Koenig, R., Luddecke, P., and Kaeberle, A. M. 1995. Detection of *Beet necrotic yellow vein virus* strains, variants and mixed infections by examining single-strand conformation polymorphisms of immunocapture RT-PCR products. J. Gen. Virol. 76:2051-2055.

Kruse M., Koenig R., Hoffmann A., Kaufmann A., Commandeur U., Solovyev A.G., Savenkov, I., and Burgermeister, W. 1994. Restriction fragment length polymorphism analysis of reverse transcription-PCR products reveals the existence of two major strain groups of *Beet necrotic yellow vein virus*. J. Gen. Virol. 75:1835-1842.

Liu, H.-Y., Sears, J. L., and Morriosn, R. H. 2003. Isolation and characterization of a carom-like virus from Calibrachoa plants. Plant Dis. 87:167-171.

Tamada, T., 1975. *Beet necrotic yellow vein virus*. CMI/AAB Descriptions of Plant Viruses, No. 144, 4pp.

Tamada, T. and Baba, T. 1973. *Beet necrotic yellow vein virus* from rhizomania-affected sugar beet in Japan. Ann. Phytopathol. Soc. Japan 43:583-586.

DEVELOPMENT OF SUGARBEET BREEDING LINES
AND GERMPLASM

R.T. LEWELLEN

<u>C81-22</u> - C81-22 (PI634216) is a narrowly based, self-sterile (S^cS^c), multigerm (MM), sugarbeet (*Beta vulgaris* L.) line with resistance to rhizomania ($Rz1$) caused by *Beet necrotic yellow vein virus.* It segregates for hypocotyl color (ca. 75% R-). C81-22 was developed from virus yellows (caused by *Beet yellows virus* and *Beet western yellows virus*) tolerant/resistant germplasm. Under *Beet chlorosis virus* (BChV) inoculated trials at Salinas, it showed sugar yield losses that were not significantly different from zero, whereas the mean loss for the commercial checks was 23%. C81-22 is moderately resistant to sugarbeet *Erwinia* (*E. carotovora betavasculorum*) and intermediate in reaction to powdery mildew caused by *Erysiphe polygoni.* Its reaction to curly top virus has not been tested, but based on its source, is likely moderately susceptible. As a line and in an experimental hybrid, it has shown very high resistance to bolting in over-wintered plantings. As a line it shows moderately high sucrose concentration and good vigor. In the experimental hybrid in comparison to the mean of four commercial hybrids in tests at Salinas and Brawley, CA, C81-22 showed higher sucrose concentration, root yield, and sugar yield, although in any one test, one or more of the commercial hybrids may have had higher sugar yield. The hybrid with C81-22 has significantly higher sucrose concentration, root yield, and sugar yield in the BChV inoculated test.

C81-22 was derived from C31/6 (PI590799) type germplasm that has been extensively used as a source of pollinators for commercial hybrids grown in California. C81-22 is the increase and reselection for resistance to rhizomania of one full-sib family produced from line R881 in 1999. In 2000, full-sib progenies from R881 were evaluated at Salinas for nonbolting tendency and components of sugar yield under virus yellows and rhizomania infected conditions. Based upon its superior progeny performance, full-sib R981-22 was increased in 2001 to produce R181-22 and was used as the pollinator to produce an experimental hybrid called R181-22H50 with the monogerm, cytoplasmic-male-sterile F_1 C790-15CMS [C790-68CMS (PI590790) x C790-15 (PI564758)]. R181-22 and R181-22H50 were evaluated in 2002. R181-22 was reselected for resistance to rhizomania to produce R381-22, released as C81-22. The source line R881 was a recombination of lines R781, R776, R481-43 (C76-43, PI578086), R481-89 (C76-89, PI578087), R482 (C82, PI593675), and R484 that had been developed and selected from C31/6 over a 12-16 year period for resistance to virus yellows, rhizomania, bolting, *Erwinia* and powdery mildew.

C81-22 should be evaluated as a source from which to develop potential pollinators for high performing, disease and bolting resistant hybrids. C81-22 segregates for resistance to rhizomania, so before commercial utilization, homozygous ($Rz1Rz1$) needs to be selected. C81-22 may be most useful for the San Joaquin Valley production area where its combination of high nonbolting tendency and disease resistance would best fit.

Seed of C81-22 will be maintained at the USDA, ARS, U.S. Agricultural Research Station, Salinas, California, and will be provided upon written request to sugarbeet breeders in sufficient quantities for reproduction. Genetic material of this release has been deposited in the National Plant Germplasm System where it will be available for research purposes, including

development and commercialization of new parental lines and cultivars. It is requested that appropriate recognition be made if this germplasm contributes to the development of a new breeding line or cultivar. The National Germplasm System and additional information on prior releases and PI numbers can be found at: www.ars-grin.gov.

<u>C842 & C842CMS</u> - C842 (PI634217) is a monogerm (*mm*), self-fertile (*S^f*), genetic-male-sterile (*A_:aa*) facilitated, random mated population. It segregates for resistance to rhizomania conditioned by the *Rz1* allele. It segregates (ca. 90% R-) for red hypocotyls. It is moderately resistant to *Curly top virus* and has genetic variability for high levels of resistance. C842 has wide variability for reaction to bolting, *Erwinia carotovora betavasculorum*, and powdery mildew caused by *Erysiphe polygoni*. The performance and combining ability of C842 have not been evaluated fully.

C842CMS (PI634218) is the cytoplasmic male sterile counterpart of C842. It will be useful to quickly develop CMS equivalents of any lines extracted or developed from C842. It may also be useful as a monogerm, CMS tester to evaluate multigerm lines for general combining ability.

C842 is a moderately based population from which selection of high quality, O-type, monogerm lines should be readily feasible. C842 was developed to retain and recombine the resistance to curly top of older monogerm, curly top resistant inbreds and lines that had been used in commercial hybrids. Up to 1995, a number of monogerm populations with resistance to rhizomania had been developed at Salinas, e.g., C869 (PI628754) and C890 (PI593700). These populations encompassed much of the germplasm from the monogerm breeding program. In 1996 these developmental populations were crossed to a bulk of monogerm inbred lines including C562 (PI590847), C546 (PI590649), C718 (PI590849), C762-17 (PI560130), and C796-43 (PI560131). After one cycle of recombination and selection for resistance to rhizomania, population 840 was produced. Population 840 and other populations similar to C869 and C890 were then crossed to a second bulk of the curly top resistant inbreds C562, C546, C718, C762-17, C796-43, C864-14 (PI560132), and C867-1 to produce population 0841 in 2000. Population 0841 was selected for resistance to rhizomania and monogerm plants were recombined through their genetic male sterile segregates to produce population 1842. Individual plants from 1842 were stringently selected for monogermity and fertile (*Aa*) plants were selfed under paper bags in the greenhouse and simultaneously crossed to an annual, male sterile, O-type index tester. The selfed or S_1 progeny were evaluated in the field under rhizomania conditions and the index populations evaluated for male sterility. On the basis of resistance to rhizomania and being O-type, stecklings from 44 S_1 progenies were recombined in 2003 to produce population 3842, released as C842. C842 has more than half but less than 75% of its germplasm from the bulked, curly top resistant, O-type, monogerm inbred lines. C562 and C546 were components of commercial curly top resistant hybrids USH7, US H9, US H10, and US H11. Selections from C718 were used in curly top resistant commercial hybrids widely grown in the Pacific Northwest. C762-17 has been an important source of curly top resistance in several breeding programs. C796-43, C864-14, and C867-1 are less well known. In addition to moderate to high resistance to curly top, these inbreds had good sugar yield combining ability and high nonbolting tendency.

C842 should be useful as a source of combined resistance to curly top and rhizomania and other diseases in a monogerm, O-type background. Sufficient genetic variability should occur to

permit population improvement and as a source of potential parental lines. C842 may be useful also as a base population from which to develop additional populations and breeding lines.

Seed of C842 and C842CMS will be maintained at the USDA, ARS, U.S. Agricultural Research Station, Salinas, California, and will be provided upon written request to sugarbeet breeders in sufficient quantities for reproduction. Genetic material of these releases has been deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new parental lines and cultivars. It is requested that appropriate recognition be made if this germplasm contributes to the development of a new breeding line or cultivar. The National Germplasm System and additional information on prior releases and PI numbers can be found at: www.ars-grin.gov.

EL0204 - see McGrath, East Lansing section.

FC201 - see Panella, Fort Collins section.

FC301 - see Panella, Fort Collins section.

M6-2 - (Yu & Lewellen). Sugarbeet (*Beta vulgaris* L.) germplasm M6-2 (Reg. no. GP ..., PI632234) was developed by the USDA-ARS, Salinas, CA and released in December 2002. M6-2 is highly resistant, if not immune, to root-knot nematode (*Meloidogyne* spp.).

M6-2 was produced by inter-pollinating more than 30 plants selected from the fifth backcross generation progeny of hybrids between M66 (PI 586688; Yu, 1996) and cultivated sugarbeet lines, including C37 (PI 590715; Lewellen et al., 1985) and C78 (PI 593671; Lewellen, 1997). F_1BC_5 plants with root-knot resistance were intercrossed. Nematode resistant F_2FC_5 plants were individually test crossed to a susceptible line. F_2 plants that performed well in test crosses and appeared to be homozygous for resistance were intercrossed to produce M6-2. M6-2 is a multigerm, biennial, self-incompatible germplasm that is heterogeneous for plant type and hypocotyl color. Approximately 25% of the seedlings have green hypocotyls. Root size and root conformation are not as uniform as the recurrent parents. Due to its wild beet ancestry, roots of M6-2 are often sprangled.

The M6-2 germplasm is resistant to multiple species of root-knot nematode, including *M. incognita* (Kofoid and White) Chitwood, *M. javanica* (Treub) Chitwood, *M. arenaria* (Neal) Chitwood, *M. hapla* Chitwood, *M. chitwoodi* Golden et al., and *M. fallax* Karssen, based on J2 larval inoculation studies in the greenhouse and monoxenic *M. incognita* and *M. javanica* infested field trials (Yu et al., 1999; Yu and Robert, 2002). The level of resistance to root-knot nematode in M6-2 and M6-1 (PI613165; Yu, 2001), a first generation backcross progeny of M66, appear to be similar. However, M6-1 is a self-compatible line with green hypocotyls, and taproots tend to be more sprangled than roots of M6-2.

Breeder seed will be maintained by the USDA-ARS and provided to sugarbeet breeders and researchers in small quantities upon written request. Recipients of seed are requested to make appropriate recognition of the source if M6-2 contributes to the development of a new population, parental line, cultivar, or hybrid. U.S. Plant Variety Protection for M6-2 will not be applied for.

INDEX OF VARIETY TRIALS, SALINAS, CA, 2003
U.S. AGRICULTURAL RESEARCH STATION

Tests were located in three field plot areas at Salinas and two at Brawley, CA. Disease nurseries were also used in Idaho, Colorado, and Minnesota. Tests at Brawley (Imperial Valley) were planted in September 2002, and harvested from May through June, 2003. Tests at Salinas were planted from November, 2002 through August, 2003, and harvested from September through December. Tests at Spence Field (Salinas) were under both rhizomania and nonrhizomania (following methyl bromide fumigation) conditions. Herbicides were not used in Block 6 trials that followed strawberries and methyl bromide fumigation. Nortron, Pyramin, Betamix, Progress, and Poast were used in the other trials. Bayleton at 2lbs material/acre was used for powdery mildew control. Lorsban-4E was applied for aphid and other insect control. The specific planting and harvest dates as well as plot size and design are shown on each test summary.

Tests are listed in the main Table of Contents for Salinas by types of material and evaluation. As an aid to find test summaries, they are listed below by ascending test (planting date) number and cross- referenced to the page number. Tests shown as n/a are not available or not included in this report.

TEST NO.	NO. ENTRIES	TEST DESCRIPTION	PAGE NO.
NOVEMBER PLANTED BOLTING EVALUATION, 2003			
103	80	Experimental hybrids	
203	100	Lines and populations	
303	50	Progeny line increases	
403	40	Progeny hybrids	
503	96	Progeny evaluation for downy mildew	n/a
603	32	CR S_1 progenies	n/a
703	96	Multigerm S_1 progenies	n/a
803	32	S_1 progenies from Y190H11	n/a
903	48	S_1 progenies from Y190H25	n/a
1003	48	S_1 progenies from Y190H31	n/a
1103	48	S_1 progenies from Y190H41	n/a
1203	96	S_1 progenies from MM lines	n/a
1303	48	S_1 progenies from N12 & N72	n/a
VIRUS YELLOWS, YIELD & PROGENY TESTS, FEBRUARY, 2003			
Beet Chlorosis Virus Inoculated & % Loss			
2103	24	Lines and populations	
2203	24	Commercial hybrids	
2303	24	Experimental hybrids	
2403	12	Progeny lines	

TEST NO.	NO. ENTRIES	TEST DESCRIPTION	PAGE NO.

VIRUS YELLOWS, YIELD & PROGENY TESTS, FEBRUARY, 2003 (cont.)

Non-inoculated Companion Tests

2503	48	Lines and populations	
2603	24	Commercial hybrids	
2703	24	Experimental hybrids	
2803	12	Progeny lines	

Yield Trials

2903	48	Testcross hybrids with S_1 progeny	
3003	48	Testcross hybrids with FS progenies	
3103	24	Topcross hybrids with C78	
3203	48	Multigerm progeny line increases	

Progeny Tests

3303	96	Multigerm S_1 progenies	n/a
3403	96	S_1 progenies from MM lines	n/a
3503	48	Monogerm lines & populations	
3603	48	Monogerm S_1 progenies	n/a
3703	32	F_1 hybrids for sugar content	n/a
3803	48	Population hybrids	
4103	32	BChV inoc. S_1 progeny from Y190H11	n/a
4203	48	BChV inoc. S_1 progeny from Y190H25	n/a
4303	48	BChV inoc. S_1 progeny from Y190H31	n/a
4403	48	BChV inoc. S_1 progeny from Y190H41	n/a

DISEASE EVALUATION TRIALS, MARCH, 2003

Powdery Mildew

5103	32	Coded Powdery Mildew	n/a
5203	32	PM evaluation of lines	

Erwinia/Powdery Mildew

5303	80	ERR/PM evaluation of lines and populations	
5403	80	ERR/PM evaluation of progeny lines	

RHIZOMANIA YIELD, EVALUATION, SELECTION TRIALS, APRIL, 2003

6103	19	Mother root selection	n/a
6203	48	Plant Introductions	
6303	48	Population hybrids	
6403-1	64	PM, SBCN, RZM evaluation & selection	
6403-2	12	SBCN evaluation of hybrids	
6503	64	S_1 progenies from N12 & N72	
6603	64	S_n progenies from 926-11 & 934-8	n/a
6703	64	S_1 progenies from C51 & R22	n/a
6803	48	S_1 progenies from MM lines	n/a
6903	32	S_1 progenies from Y190H25	n/a

TEST 2503. PERFORMANCE OF LINES, SALINAS, CA, 2003

48 entries x 8 reps., RCB(e); 3 subtests (16 x 8, RCB(e)
1-row plots, 22 ft. long

Planted: March 5, 2003
Harvested: September 29, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/07	Downey Mildew 9/29	Powdery Mildew 7/02	Virus Yellows 7/21	Virus Yellows 8/15	Virus Yellows 9/02	Virus Yellows Mean
2503-1: Multigerm, O.P. lines, 16V x 8R, RCB(e)													
Y291H50	C790-15CMS x RZM Y191	16671	51.40	16.21	148	85.2	1.9	4.4	0.9	1.5	1.5	1.9	1.4
Phoenix	9-16-02, Holly Hybrids	13719	48.47	14.18	159	83.4	0.5	5.5	2.0	2.5	2.8	2.9	2.5
Beta 4001R	9-2002	17628	54.67	16.14	164	87.0	1.5	2.3	1.3	2.4	2.6	3.3	2.4
01-US75	Inc. 00-US75, (US75)	11244	42.07	13.39	159	80.3	1.0	7.3	2.3	2.4	2.6	2.9	2.5
01-C37	Inc. U86-37, (C37)	10223	34.11	14.95	153	82.7	4.1	6.9	1.0	1.6	1.5	1.6	1.4
99-C31/6	Inc. F86-31/6, (C31/6)	13125	44.04	14.90	155	82.9	1.5	4.3	1.8	1.6	1.8	1.9	1.8
R276-89	RZM-% R076-89	12313	40.24	15.31	149	82.7	1.5	4.3	1.6	1.1	1.1	1.8	1.4
R176-89-5NB-4	Inc. R976-89-5NB-4	11562	36.63	15.79	155	83.2	2.8	2.8	2.3	1.4	1.6	1.4	1.7
99-C46/2	Inc. U86-46/2, (C46/2)	12612	40.51	15.54	152	84.4	2.5	4.6	1.1	2.0	1.5	2.0	1.7
R278	RZM R178, (C78/3)	12843	42.50	15.10	117	83.9	1.0	4.1	1.9	2.0	2.1	2.4	2.1
Y169	RZM-ER-% Y969, (C69/2)	14216	44.84	15.86	144	84.2	2.1	2.9	1.8	2.1	1.6	2.1	1.9
Y290	RZM-% Y090	14784	45.05	16.41	148	85.3	1.9	4.9	1.9	1.5	1.1	1.3	1.4
Y292	Inc. FS(C),Cyc 1,Syn 1	14202	44.49	16.00	155	84.2	2.8	4.5	1.6	1.5	1.8	1.8	1.7
Y291	RZM Y191	14026	44.20	15.85	150	84.7	1.1	4.6	1.4	1.5	1.5	1.6	1.5
R180	RZM-ER-% R980, (C80/2)	14963	47.52	15.75	144	84.6	1.3	5.1	1.1	1.4	1.6	1.9	1.5
02-FC1015	RZM 01-FC1014H7	11389	35.97	15.82	149	84.0	1.0	4.8	2.1	1.8	2.0	2.0	2.0
Mean		13470.0	43.54	15.45	150.1	83.9	1.8	4.6	1.6	1.8	1.8	2.0	1.8
LSD (.05)		1087.8	3.10	0.66	11.0	2.0	1.6	0.6	0.7	0.6	0.6	0.6	0.4
C.V. (%)		8.2	7.20	4.28	7.4	2.4	91.0	13.0	44.0	36.6	35.6	28.8	20.8
F value		26.1**	24.35**	11.61**	6.9***	4.3***	2.6***	39.2***	3.1**	3.3**	4.9**	7.2***	8.8**

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TEST 2503. PERFORMANCE OF LINES, SALINAS, CA, 2003

48 entries x 8 reps., RCB(e). ANOVA across tests to compare means.

	Sugar Lbs	Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/07	Downey Mildew 9/29	Powdery Mildew 7/02	Virus Yellows 7/21	Virus Yellows 8/15	Virus Yellows 9/02	Virus Yellows Mean
Mean	12770.6	42.35	15.06	146.3	83.1	2.3	4.1	2.0	2.0	2.2	2.3	2.2
LSD (.05)	1148.6	3.16	0.82	11.0	2.5	2.0	0.6	0.8	0.7	0.6	0.6	0.4
C.V. (%)	9.1	7.57	5.52	7.6	3.0	86.5	15.5	37.5	33.1	28.3	24.6	18.5
F value	18.5**	16.53**	10.54**	3.8***	3.4***	2.1**	23.4**	7.2**	9.9**	14.5**	16.7**	26.5**

TEST 2503.   PERFORMANCE OF LINES, SALINAS, CA, 2003

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | RJAP | Downey Mildew | | Powdery Mildew | Virus Yellows Scores | | | |
		Sugar Lbs	Beets Tons	%	No.	%	5/07	9/29	7/02	7/21	8/15	9/02	Mean
2503-2:	Multigerm lines with Bvm germplasm												
Beta 6600	rec'd 7-11-00	15953	43.79	18.21	152	87.8	1.3	4.5	1.5	3.0	3.3	4.0	2.9
Beta 4776R	9-2002	12924	44.54	14.50	156	83.4	2.0	2.3	3.0	4.1	4.3	4.1	3.9
R221	RZM-% R021,(C26,C27)	12721	42.32	15.01	148	84.1	2.4	4.9	1.5	1.8	1.3	1.9	1.6
01-SP22-0	Inc.00-SP22-0,(SP22-0)	9444	34.62	13.64	143	82.3	2.0	4.6	4.9	4.0	4.5	4.9	4.6
Z210	Inc.Z010(C),(Pol.gp)	11576	33.66	17.20	144	83.2	3.0	4.6	3.8	3.1	3.1	3.9	3.5
Y167	RZM-ER-% Y967,(C67/2)	14604	46.91	15.56	148	82.5	1.4	3.4	1.4	2.0	1.6	1.8	1.7
Y171	RZM-ER-% Y971	13465	44.83	15.01	150	83.7	4.4	5.5	1.5	1.6	1.6	1.9	1.7
Y275	RZM-% Y075	11855	39.33	15.09	146	83.3	3.3	4.5	2.8	2.0	1.9	1.6	2.1
Y277	RZM Y175,Y167,...(C)	11578	40.26	14.41	136	81.9	1.8	4.1	2.4	2.1	2.1	2.4	2.3
2921	RZM-% 0921 (A,aa)	12676	42.42	14.93	144	82.2	3.3	4.6	2.0	1.4	1.8	1.8	1.7
P227	PMR-RZM-NB P027(C),CP03	9758	34.31	14.21	142	82.0	3.4	4.9	1.6	1.5	1.8	2.0	1.7
P228	PMR-RZM-NB P028(C),CP04	11408	39.55	14.44	143	82.1	3.4	3.8	2.3	1.5	2.0	2.1	2.0
P229	PMR-RZM-NB P029(C),CP05	13002	43.79	14.85	140	83.8	3.3	2.3	2.1	1.3	1.4	1.5	1.6
P230	PMR-RZM-NB P030(C),CP06	11478	40.29	14.29	147	81.8	3.5	3.1	2.4	1.4	1.9	2.1	1.9
P207/8(Sp)	Inc. P007/8,CP07	10542	37.08	14.18	142	82.8	3.9	2.8	2.3	2.0	1.8	1.9	2.0
P207/8(Iso)	PMR-RZM-NB P007/8,CP07	10925	39.00	14.02	150	82.0	4.3	2.5	2.0	1.6	2.0	2.1	1.9
Mean		12119.3	40.42	14.97	145.6	83.1	2.9	3.9	2.3	2.2	2.3	2.5	2.3
LSD (.05)		1129.7	3.21	0.85	8.3	2.5	2.1	0.6	0.7	0.7	0.6	0.6	0.4
C.V. (%)		9.4	8.03	5.73	5.8	3.0	73.9	16.2	31.9	32.4	27.7	22.2	19.1
F value		17.6**	12.18**	15.22**	2.9**	2.9**	1.7NS	22.1**	12.5**	13.9**	19.8**	29.9**	34.1**

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NOTES: Tests 2103 through 3803 in 2003 at Spence Field, Salinas, CA, were grown following strawberries in soil fumigated with methylbromide/chloropicrin. Only one application of Nortron-SC was used for weed control. RHIZOMANIA, CYST NEMATODE, and other soil-borne problems were not observed. There were, however, significant foliar disease problems. POWDERY MILDEW was controlled until late in the season. RUST was fairly severe and differentially affected entries. In general for rust, germplasm developed at Salinas under exposure to rust was more tolerant than non-Salinas germplasm entries. DOWNEY MILDEW infection started early and persisted through the season. Downy mildew also appeared to differentially affect performance. Tests not inoculated with BChV developed yellowing that was probably BWYV or BChV.

TEST 2503. PERFORMANCE OF LINES, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/07	Powdery Mildew 9/29	Virus Yellows 7/02	7/21	8/15	9/02	Mean
2503-3:	**Multigerm, s^f,Aa populations**												
Eagle	9-16-02, Holly Hybrids	13311	45.50	14.63	145	84.7	1.4	5.4	2.4	3.1	4.0	3.9	3.3
Beta 4430R	9-2002	12169	45.20	13.45	156	84.2	3.3	3.1	2.9	4.4	4.4	4.3	4.0
2931	RZM-% 0931(A,aa)	11315	40.33	14.02	146	80.3	3.4	3.1	2.1	1.9	2.5	2.0	2.1
2941	RZM-% 0941(A,aa)	14035	47.47	14.77	148	83.7	1.4	3.6	1.5	1.5	2.0	1.8	1.7
Z225	RZM-% Z025(A,aa)	11827	39.55	15.06	143	80.9	2.3	4.6	2.3	2.3	2.3	2.9	2.4
CR211	RZM-% CR011(A,aa)	12808	44.84	14.29	146	81.6	1.4	4.6	1.9	1.5	2.0	2.1	1.9
2933	RZM-% 9933(A,aa)	14164	46.46	15.23	146	82.2	2.1	4.4	1.8	1.9	2.3	2.3	2.0
2942	RZM-% 0942(A,aa)	11173	36.93	15.07	147	79.6	2.1	2.8	1.6	1.5	2.4	2.4	2.0
2943(C)	MM,s^f,Aa,%S(C)aa x A	11967	39.72	15.06	138	82.0	1.6	2.9	2.4	1.8	2.9	2.5	2.4
CR214	Inc. 1241,2,3(C),(Aa)	12459	43.55	14.25	142	82.3	1.5	3.5	2.4	2.5	2.6	2.4	2.5
N224	RZM-NR N124(A,aa)	10187	38.53	13.25	138	80.4	4.5	3.9	2.4	1.9	2.8	2.1	2.3
R278H23	Z025-9aa x RZM R178	11953	39.30	15.18	142	82.0	2.3	3.5	3.3	3.0	3.8	3.1	3.3
R278H41	RZM 1941aa x RZM R178	13287	44.93	14.79	137	82.2	2.6	3.8	1.8	1.6	1.6	1.8	1.7
Y291H41	RZM 1941aa x RZM Y191	14115	46.00	15.34	143	84.6	1.6	4.5	1.6	1.5	1.8	1.6	1.6
Y291H23	Z025-9aa x RZM Y191	12727	41.02	15.52	138	83.8	1.6	3.6	2.9	2.4	3.0	2.8	2.8
Y291H5	C833-5HO x RZM Y191	16061	50.39	15.96	137	84.1	2.1	5.0	1.4	1.9	1.8	2.0	1.8
Mean		12722.4	43.11	14.74	143.2	82.4	2.2	3.9	2.2	2.2	2.6	2.5	2.4
LSD (.05)		1262.7	3.31	0.92	8.8	2.9	1.9	0.6	0.6	0.6	0.6	0.6	0.4
C.V. (%)		10.0	7.77	6.33	6.2	3.5	87.2	16.7	28.9	29.8	21.5	22.5	14.9
F value		10.1**	10.38**	4.94**	2.9**	2.5**	1.7NS	11.5**	6.2**	1.7NS	6.2**	12.0**	17.1**14.2**30.1**

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NOTES (cont.): Counts for **DOWNEY MILDEW INFECTED** plants were made once on 5/07/03 but only indicated the plants with evidence of DM at that time and are estimates. Infection and re-infection continued over most of the season and caused considerable canopy and crown damage in plants in some varieties. **RUST** was particularly severe in the late winter and spring and caused continuing defoliation. Rust was not scored.

Even though not inoculated with **VIRUS YELLOWS**, Tests 2503 through 2803 were scored for virus yellows. This yellows infection was later and less severe than the inoculated companion Tests 2103 through 2403.

TEST 2803. PERFORMANCE OF PROGENY LINES SELECTED FOR VIRUS YELLOWS RESISTANCE WITHOUT BchV, SALINAS, CA, 2003

12 entries x 8 reps., RCB
1-row plots, 22 ft. long

Planted: March 5, 2003
Harvested: September 22, 2003

Variety	Description	Acre Yield Sugar Lbs	Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/07	Powdery Mildew 9/29	Virus Yellows Scores 7/02	7/21	8/15	9/02	Mean
Checks													
01-SP22-O	Inc.00-SP22-O,(SP22-O)	8260	30.95	13.32	129	81.6	1.0	3.1	3.5	3.0	4.9	5.1	4.1
R176-89-5-4	Inc. R976-89-5-4	12371	39.25	15.77	135	84.9	0.6	1.9	1.4	0.8	1.9	1.6	1.4
Progeny lines from full sibs													
R278-4	Inc. R078-4	9125	34.77	13.05	126	81.9	1.6	2.4	2.0	1.8	2.6	2.1	2.1
R280/2-9	Inc. R080/2-9	12044	36.75	16.39	113	84.3	0.4	4.9	1.3	1.9	2.8	3.0	2.2
Progeny lines from S₁'s													
2930-19	RZM 1930-19aa x A,C930-19	10339	35.67	14.44	120	84.0	1.0	1.1	1.5	1.0	2.0	1.6	1.5
2930-35	RZM 1930-35aa x A,C930-25	9276	29.07	15.88	136	82.6	0.8	3.6	2.1	3.0	3.8	4.1	3.3
2929-45	9929-45aa x A	9658	32.48	14.79	128	83.7	2.8	2.5	1.8	1.3	2.6	2.5	2.0
2936-10	RZM 0936-10aa x A	8125	27.71	14.66	129	83.4	1.1	2.5	2.1	1.4	2.4	1.8	1.9
2936-16	0936-16aa x A	9696	29.89	16.23	136	80.7	1.0	1.5	1.5	2.1	3.5	3.3	2.6
R181-22	Inc. R981-22,C81-22	12706	39.05	16.26	137	85.2	0.8	3.0	1.3	1.5	3.0	2.3	2.0
Monogerm populations													
2842	RZM 1842mmaa x A	12102	40.26	15.01	126	83.1	0.1	4.5	1.3	1.9	2.5	2.9	2.1
2837	RZM,T-O 1836H7-#(C)mmaa x A	12159	38.74	15.68	110	82.8	0.3	4.9	0.9	1.6	3.0	3.1	2.2
Mean		10488.4	34.55	15.12	127.0	83.2	1.0	3.0	1.7	1.8	2.9	2.8	2.3
LSD (.05)		1331.1	4.09	0.62	10.2	1.9	1.0	0.7	0.7	0.6	0.7	0.6	0.4
C.V. (%)		12.8	11.88	4.12	8.1	2.3	105.3	23.2	38.7	35.6	23.7	20.3	15.8
F value		12.8**	9.25**	25.78**	5.8**	4.0**	4.0**	26.7**	8.6**	9.8**	11.4**	27.8**	33.9**

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NOTE: See test 2403.

TEST 3203. EVALUATION OF SELECTED MULTIGERM PROGENY LINES, SALINAS, CA, 2003

48 entries x 4 reps., sequential   Planted: March 5, 2003
1-row plots, 11 ft. long   Harvested: October 2, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/08	Powdery Mildew 9/19	Root Rot %
Checks									
Y290	RZM-% Y090	13740	44.34	15.38	143	83.3	0.3	5.0	0.0
Z210	Inc. Z010(C)	12368	37.48	16.42	145	84.9	0.3	5.3	1.6
Inc. S₁ progeny lines									
Z025-9	Z025-9aa x A, CZ25-9	11011	33.86	16.17	143	81.9	0.0	2.5	0.0
Z225-9	RZM Z025-9(A,aa),CZ25-9	12548	39.70	15.77	143	82.6	0.0	2.8	0.0
2930-35	RZM 1930-35aa x A,C930-35	9636	31.44	15.27	130	83.9	1.0	4.8	6.9
0930-19	8930-19aa x A,C930-19	12418	43.09	14.50	132	83.0	1.0	3.3	0.0
1930-19	NB 8930-19(A,aa),C930-19	11133	39.10	14.25	141	82.4	0.3	3.8	0.0
2930-19	RZM 1930-19aa x A,C930-19	12908	43.93	14.65	134	83.1	0.8	2.5	0.0
1927-4	RZM 9927-4aa x A,C927-4	14307	49.17	14.68	127	84.7	0.3	6.5	0.0
2927-4	RZM 1927-4(A,aa),C927-4	14708	47.96	15.20	134	84.0	0.5	6.5	0.0
1924-2	RZM 9924-2aa x A	12124	37.89	16.00	118	84.1	0.0	3.0	0.0
1929-4	RZM 9929-4aa x A	14173	45.75	15.47	139	82.2	0.0	3.0	0.0
2929-45	9929-45aa x A	11015	38.69	14.05	130	81.9	0.5	3.8	0.0
2936-10	RZM 0936-10aa x A	10354	35.27	14.57	139	84.4	0.3	5.5	0.0
2936-16	0936-16aa x A	12405	37.69	16.48	132	80.7	1.0	3.8	0.0
2931-3	Inc. 0931-3(A,aa)	12816	41.51	15.40	141	82.2	0.8	2.5	0.0
2931-20	Inc. 0931-20(A,aa)	8805	33.80	13.10	132	78.4	1.3	4.5	0.0
2941-20	Inc. 0941-20(A,aa)	12293	39.30	15.63	134	83.1	0.8	4.5	0.0
2933-7	Inc. 0933-7(A,aa)	11232	38.09	14.77	145	82.2	1.3	5.5	0.0
2933-14	Inc. 0933-14(A,aa)	11233	35.87	15.60	145	83.9	0.8	3.0	0.0
2933-17	Inc. 0933-17(A,aa)	13210	42.12	15.70	132	82.9	0.0	5.3	0.0
CR210-2	Inc. CR910-2	11403	43.13	13.27	136	76.9	0.0	6.0	0.0
CR211-7	Inc. CR911-7	13620	46.96	14.57	136	79.8	1.3	5.3	0.0

TEST 3203. EVALUATION OF SELECTED MULTIGERM PROGENY LINES, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield		Sucrose %	Beets/ 100' No.	RJAP %	Downey Mildew 5/08	Powdery Mildew 9/19	Root Rot %
		Sugar Lbs	Beets Tons						
Increase of FS progeny lines									
P207/8(Iso)	PMR-RZM-NR P007/8,CP07	10176	35.67	14.27	132	81.3	1.5	2.0	0.0
P207/8(Sp)	Inc. P007/8	9864	34.86	14.20	127	81.4	1.3	2.5	0.0
P229-8	Inc. P029-8	10812	35.87	15.00	134	80.7	0.8	4.8	0.0
P229-20	Inc. P029-20	11019	39.10	13.93	125	79.1	0.5	5.0	0.0
P230-10	Inc. P030-10	11816	39.70	14.85	145	80.7	1.3	3.8	0.0
P230-17	Inc. P030-17	13368	44.13	15.15	148	82.8	0.3	4.8	0.0
R278-4	Inc. R078-4	11708	43.33	13.50	132	86.6	0.0	4.5	0.0
R278-2	Inc. R078-2	9204	32.65	14.05	145	78.6	2.3	5.0	0.0
R278-7	Inc. R078-7	11073	36.07	15.40	134	82.9	0.8	5.5	0.0
R278-14	Inc. R078-14	10880	35.87	15.02	134	80.3	0.5	3.0	0.0
R278-16	Inc. R078-16	13193	41.39	15.93	130	83.0	0.5	4.0	0.0
R278-27	Inc. R078-27	9256	32.85	14.10	130	80.5	0.3	4.5	0.0
R280/2-9	Inc. R080/2-9	13676	41.92	16.30	123	84.4	0.3	5.5	0.0
R280-6	Inc. R080-6	15043	48.37	15.55	143	84.0	0.0	5.0	0.0
R270-18	Inc. R070-18	11701	38.29	15.23	141	80.5	0.8	5.8	0.0
Y269-8	Inc. Y069-8	12743	38.49	16.52	134	81.5	0.0	3.3	0.0
Y269-18	Inc. Y069-18	13158	41.51	15.83	132	84.8	0.0	4.0	0.0
Y269-39	Inc. Y069-39	13035	41.51	15.70	141	82.7	0.3	2.0	0.0
Y276-89	RZM-% R076-89	10098	33.25	15.23	139	83.0	0.3	4.8	0.0
R243-14	Inc. R043-14	8296	29.02	14.40	134	82.8	1.5	3.0	0.0
Y267-21	Inc. Y067-21	12853	41.72	15.40	136	82.0	0.3	4.3	0.0
Y267-24	Inc. Y067-24	11998	40.51	14.85	145	82.7	1.0	3.8	0.0
Y267-34	Inc. Y067-34	12831	41.51	15.45	145	83.1	1.0	3.8	0.0
Y271-14	Inc. Y071-14	11591	38.89	14.98	139	83.3	0.5	5.5	0.0
Y275-16	Inc. Y075-16	11339	36.88	15.35	141	83.9	0.0	6.3	0.0

TEST 3203. EVALUATION OF SELECTED MULTIGERM PROGENY LINES, SALINAS, CA, 2003

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | RJAP | Downey Mildew | Powdery Mildew | Root Rot |
		Sugar Lbs	Beets Tons	%	No.	%	5/08	9/19	%
Mean		11879.0	39.36	15.07	136.3	82.4	0.6	4.3	0.2
LSD (.05)		2442.0	7.56	1.10	17.3	3.1	1.2	1.0	1.3
C.V. (%)		14.7	13.74	5.21	9.1	2.7	152.6	16.7	542.0
F value		3.2**	2.85**	4.36**	1.2NS	2.9**	1.4NS	11.7**	4.5**

NOTES: See test 7403 for performance under rhizomania and tests 303 for bolting tendency. Also see tests 403, 2903, 3003, 8103 & 8203 for performance in experimental hybrids.

The FS and S_1 derived lines in this test were selected from FS and S_1 progenies evaluated for disease resistance, bolting tendency, and performance. The selected progenies were increased and test-crossed to C833-5CMS and C790-15CMS monogerm testers. These progenies are the ones primarily evaluated in progeny tests in 2001 and increased in 2002.

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TEST 2103. PERFORMANCE OF LINES UNDER BChV INFECTION, SALINAS, CA, 2003

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: March 5, 2003
Harvested: October 1, 2003
Inoc. BChV: May 9, 2003

Variety	Description	Acre Yield				Beets/100'	RJAP	Downey Mildew	Powdery Mildew	Virus Yellows Scores				
		Sugar Lbs	Loss[1] %	Beets Tons	Sucrose %	No.	%	5/07	9/29	7/02	7/21	8/15	9/02	Mean
Checks														
01-SP22-0	Inc.00-SP22-0,(SP22-0)	5257	44.34	20.57	12.81	144	79.7	3.3	5.0	5.5	5.3	5.4	6.0	5.5
01-US75	Inc.00-US75,(US75)	7370	34.45	30.30	12.15	150	79.7	2.5	6.6	3.3	3.6	4.6	5.0	4.1
01-C37	Inc.U86-37,(C37)	8944	12.51	31.09	14.32	158	86.6	6.6	6.1	1.9	2.1	2.0	2.5	2.1
99-C31/6	Inc.F86-31/6,(C31/6)	10364	21.04	36.53	14.18	149	84.3	2.1	4.6	2.4	1.8	1.9	2.5	2.1
VYR O.P. lines														
Y169	RZM-ER-% Y969,(C69/2)	12285	13.58	38.19	16.08	152	86.0	2.5	3.0	3.0	2.9	2.8	3.4	3.0
R276-89	RZM-% R076-89	10161	17.48	34.21	14.88	154	84.0	4.3	3.5	2.5	1.4	1.6	2.1	1.9
R176-89-5NB-4	Inc.R976-89-5NB-4	9511	17.74	31.14	15.29	158	84.7	2.6	3.3	2.5	2.1	2.1	1.8	2.1
Z210	Inc.Z010(C),(Polish gp)	7447	35.67	23.43	15.89	150	86.3	3.5	4.3	4.6	5.1	5.0	5.5	5.1
99-C46/2	Inc.U86-46/2,(C46/2)	9317	26.13	31.08	14.90	150	85.0	6.8	4.3	3.0	3.1	2.8	3.1	3.0
R278	RZM R178	9020	29.77	31.54	14.29	120	82.4	2.9	4.0	3.6	3.3	2.9	3.9	3.4
R180	RZM-ER-% R980,(C80/2)	11392	23.87	37.03	15.38	155	85.8	3.3	4.4	3.5	3.5	2.9	3.6	3.4
Y290	RZM-% Y090	11754	20.50	38.42	15.31	152	83.7	2.3	4.6	2.3	2.1	2.0	2.8	2.3
Y291	RZM Y191	10833	22.77	36.08	14.99	146	84.4	2.9	4.5	2.8	3.0	2.9	3.1	2.9
Y292	Inc.FS(C),Cycle 1,Syn 1	11277	20.60	36.98	15.26	155	83.2	4.4	4.6	2.9	2.4	2.5	2.9	2.7
VYR O.P. lines with Bvm														
Y275	RZM-% Y075	9854	16.88	33.63	14.64	154	83.5	5.6	4.0	3.8	2.3	2.4	2.9	2.8
R221	RZM-% R021,(C26,C27)	11059	13.07	37.60	14.69	155	84.2	6.4	4.4	2.4	2.4	2.4	3.3	2.6
MM,S[f],Aa populations														
2921	RZM-% 0921 (A,aa)	9793	22.74	33.71	14.52	152	84.5	7.0	4.9	3.0	2.6	2.5	3.0	2.8
2931	RZM-% 0931 (A,aa)	9220	12.01	31.94	14.41	150	83.7	5.4	3.3	3.5	3.0	3.3	3.6	3.3
2941	RZM-% 0941 (A,aa)	12387	11.74	42.34	14.61	158	84.8	3.8	3.6	2.9	2.8	2.8	3.4	2.9
2942	RZM-% 0942 (A,aa)	9433	15.57	30.86	15.28	150	81.7	2.1	2.1	2.8	3.1	2.9	3.6	3.1

A49

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Loss[1] %	Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/07	Powdery Mildew 9/29	VY 7/02	VY 7/21	VY 8/15	VY 9/02	Mean
Population hybrids														
Y291H41	RZM 1941aa x RZM Y191	11446	18.91	38.26	14.95	147	85.3	4.9	4.0	2.6	2.5	2.4	2.8	2.6
Y291H23	Z025-9aa x RZM Y191	9656	24.13	31.13	15.55	149	85.0	4.1	3.8	3.8	3.9	4.8	4.9	4.3
Commercial hybrid checks														
Beta 4430R	9-2002	7532	38.11	30.84	12.23	166	82.1	4.1	3.3	5.3	6.0	5.4	5.0	5.4
Beta 4776R	9-2002	9490	26.57	34.82	13.64	159	83.9	1.9	2.5	4.5	5.1	4.9	5.0	4.9
Mean		9783.4		33.41	14.59	151.3	83.9	4.0	4.1	3.3	3.1	3.1	3.6	3.3
LSD (.05)		969.4		2.83	0.65	9.9	2.5	2.5	0.6	0.6	0.5	0.6	0.6	0.3
C.V. (%)		10.1		8.61	4.53	6.6	3.0	65.0	15.1	19.0	17.2	18.3	16.0	10.4
F value		23.9**		22.24**	18.98**	5.3**	4.0**	3.1**	21.4**	18.4**	39.1**	34.4**	30.4**	79.7·

[1]Test 2103 and Test 2503 are companion tests. Test 2103 was inoculated May 9, 2003 with *Beet chlorosis virus* (BChV).
% loss is the relative sugar yield loss calculated from the corresponding means in each test.

Notes: Virus yellows foliar symptoms were scored on a scale of 0 to 9, where 9 = 90-100% of the mature leaf area yellowed. Scores were made on 7/2, 7/21, 8/15 and 9/2/03 by JAO.

Correlations within VY inoculated test 2103

	SY	RY	%S	RJAP	%loss
VY mean	-.68**	-.61**	-.48*	-.40NS	.79**
VY 9/02	-.65**	-.60**	-.45*	-.44*	.76**
VY 8/15	-.68**				.77**
VY 7/21	-.63**				.77**
VY 7/02	-.66**				.77**
% sugar	.62**				

Correlations between corresponding tests
Non-inoculated test (Test 2503)

VY Inoc.	SY	%S	VY mean	VY 9/02	VY 8/15	VY 7/21	VY 7/0
SY	.84**						
%S		.89**					
VY mean			.94**				
VY 9/02				.91**			
VY 8/15					.92**		
VY 7/21						.91**	
VY 7/02							.83**

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TEST 2403. PERFORMANCE OF PROGENY LINES SELECTED FOR VIRUS YELLOWS RESISTANCE, SALINAS, CA, 2003

12 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: March 5, 2003
Harvested: September 30, 2003
Inoc. BChV: May 9, 2003

Variety	Description	Acre Yield — Sugar Lbs	Acre Yield — Loss[1] %	Acre Yield — Beets Tons	Acre Yield — Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/07	Powdery Mildew 9/29	Virus Yellows Scores 7/02	7/21	8/15	9/02	Mean
Checks														
01-SP22-O	Inc. 00-SP22-O, (SP22-O)	5394	34.70	21.19	12.69	145	79.2	2.4	5.1	5.4	5.3	5.8	6.3	5.7
R176-89-5-4	Inc. R976-89-5-4	11074	10.48	35.42	15.60	155	84.8	1.6	3.3	2.3	1.8	2.4	2.4	2.2
Progeny lines from full sibs														
R278-4	Inc. R078-4	8451	7.39	31.27	13.44	140	85.0	3.6	3.3	4.0	3.3	3.4	3.1	3.4
R280/2-9	Inc. R080/2-9	11079	8.01	35.45	15.64	139	83.6	1.4	5.6	2.9	4.6	4.5	4.0	4.0
Progeny lines from S$_1$'s														
2930-19	RZM 1930-19aa x A, C930-19	9246	10.57	32.11	14.39	146	81.8	3.4	2.5	2.9	2.0	2.1	2.1	2.3
2930-35	RZM 1930-35aa x A, C930-35	6403	30.97	20.86	15.30	141	82.5	3.8	5.1	4.8	4.8	5.4	5.1	5.0
2929-45	9929-45aa x A	7355	23.85	26.21	14.01	138	82.5	6.4	2.6	3.8	2.4	3.6	3.6	3.3
2936-10	RZM 0936-10aa x A	7622	6.19	27.60	13.80	144	82.5	5.3	4.0	3.3	1.8	2.0	2.1	2.3
2936-16	0936-16aa x A	8872	8.50	28.14	15.76	141	80.3	3.6	2.5	3.4	2.9	3.4	3.1	3.2
R181-22	Inc. R981-22, C81-22	11361	10.59	36.13	15.70	146	85.7	2.9	4.1	2.8	2.6	3.3	2.9	2.9
Monogerm populations														
2842	RZM 1842mmaa x A, C842	8743	27.76	31.65	13.85	137	82.3	2.4	5.6	3.9	4.5	4.5	4.6	4.4
2837	RZM,T-O 1836H7-#(C)mmaa x A	8981	26.14	30.13	14.89	130	82.5	0.9	6.3	4.0	4.9	4.8	4.1	4.4
Mean		8715.1		29.68	14.59	141.7	82.7	3.1	4.2	3.6	3.4	3.8	3.6	3.6
LSD (.05)		1011.5		3.05	0.62	9.6	2.1	2.1	0.6	0.7	0.5	0.6	0.6	0.4
C.V. (%)		11.7		10.30	4.25	6.8	2.5	68.9	14.4	18.4	14.3	17.2	15.6	10.4
F value		26.8**		22.48**	22.40**	3.1**	6.6**	4.3**	40.5***	14.4**	60.4***	29.5***	40.0***	72.1*

A51

TEST 2403. PERFORMANCE OF PROGENY LINES SELECTED FOR VIRUS YELLOWS RESISTANCE, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield				Beets/ 100'	Downey Mildew	Powdery Mildew	Virus Yellows Scores				
		Sugar Lbs	Loss[1] %	Beets Tons	Sucrose %	RJAP No. %	5/07 %	9/29 %	7/02	7/21	8/15	9/02	Mean

[1] Test 2403 and Test 2803 are companion tests. Test 2403 was inoculated May 9, 2003 with Beet chlorosis virus (BChV). % loss is the relative sugar yield loss calculated from the corresponding means in each test.

Notes: Virus yellows foliar symptoms were scored on a scale of 0 to 9, where 9 = 90-100% of the mature leaf area yellowed. Scores were made on 7/2, 7/21, 8/15 and 9/2/03 by JAO.

Correlations within VY inoculated test 2403

	SY	RY	%S	RJAP	%loss
VY mean	-.57NS	-.60*	-.30NS	-.45NS	.83**
VY 9/02	-.59*	-.61*	-.33NS	-.49NS	.86**
VY 8/15	-.46NS				.80**
VY 7/21	-.35NS				.69*
VY 7/02	-.88**				.80**
% sugar	.69*				

A52

Correlations between corresponding tests

Non-inoculated test (Test 2803)

VY Inoc.	SY	%S	VY mean	VY 9/02	VY 8/15	VY 7/21	VY 7/02
SY	.83**						
%S		.93**					
VY mean			.85**				
VY 9/02				.93**			
VY 8/15					.77**		
VY 7/21						.78**	
VY 7/02							.68*

NOTES: See test 2803. Progeny lines are increases of FS and S[1] progenies in part selected for their per se performance under VY (BYV/BWYV) inoculated conditions at Salinas and Davis, CA, as well as resistance to rhizomania, bolting, and other diseases. SP22-0 is the pollinator of USH20. 2842 was released as C842. R181-22 was released as C81-22. R176-89-5-4 was released as C76-89-5-4.

TEST 8003. PERFORMANCE OF LINES UNDER RHIZOMANIA, SALINAS, CA, 2003

48 entries x 8 reps, RCB(E); 3 subtests at 16 entries x 8 reps, RCB(e)
1-row plots, 22 ft. long

Planted: April 25, 2003
Harvested: October 20, 2003

Variety	Resist	Description	Sugar Yield Sugar Lbs	Sugar Yield Beets Tons	Sucrose %	Beets/100' No.	Root Rot %	Missing Feet No.	RJAP %	Powdery Mildew 10/17
8003-1: Multigerm, O.P. lines, 16V x 8R, RCB(e)										
Y291H50	Rz1,C51	C790-15CMS x RZM Y191	8870	28.99	15.36	186	8.4	1.1	85.6	3.4
Phoenix	Rz1	9-16-02, Holly Hybrids	7772	26.05	15.00	160	10.6	2.9	86.8	3.8
Beta 4001R	Rz1	9-2002, Betaseed	9889	30.66	16.13	208	4.9	0.1	87.2	1.8
Roberta	rzrz	3/25/03, susc.ck.	2986	11.22	13.27	201	5.7	4.6	85.6	2.4
01-C37	rzrz	Inc. U86-37, (C37)	4964	16.45	15.05	202	6.6	1.8	83.8	5.4
99-C31/6	rzrz	Inc. F86-31/6, (C31/6)	4190	15.32	13.56	187	4.3	0.9	83.8	2.3
R276-89	Rz1	RZM-% R076-89	8046	25.01	16.11	187	0.3	0.1	85.9	2.6
R176-89-5NB-4	Rz1	Inc. R976-89-5NB-4	7085	21.65	16.33	198	4.2	0.6	84.8	2.6
99-C46/2	rzrz	Inc. U86-46/2, (C46/2)	5369	18.17	14.86	197	8.1	0.9	84.1	2.8
R278	Rz1	RZM R178, (C78/3)	8832	27.00	16.39	168	1.1	0.5	85.4	3.3
Y169	Rz1	RZM-ER-% Y969, (C69/2)	9027	28.15	15.99	198	8.4	1.4	86.4	2.4
Y290	Rz1	RZM-% Y090,Cyc3,Syn1	8972	27.80	16.13	201	9.1	0.6	85.9	3.3
Y292	Rz1,C51	Inc. FS(C),Cyc1,Syn1	9298	29.32	15.93	197	10.9	0.8	85.0	3.9
Y291	Rz1,C51	RZM Y191,Cyc2,Syn1	8660	27.55	15.89	194	7.0	0.4	84.4	4.0
R180	Rz1	RZM-ER-% R980, (C80/2)	8167	25.21	16.26	187	8.8	0.6	86.1	3.9
02-FC1015	Rz1	RZM 01-FC1014H7(monogerm)	7309	22.05	16.66	192	5.5	1.1	83.4	3.1
Mean			7464.7	23.79	15.56	191.4	6.5	1.2	85.3	3.2
LSD (.05)			1006.7	3.30	0.58	17.4	6.4	1.9	1.6	0.8
C.V. (%)			13.6	13.99	3.79	9.2	100.1	162.9	1.9	26.9
F value			31.9**	23.87**	22.47**	4.0**	1.8NS	3.0**	3.8**	8.7**

TEST 8003. PERFORMANCE OF LINES UNDER RHIZOMANIA, SALINAS, CA, 2003

48 entries x 8 reps, RCB(E). ANOVA across tests to compare means.

			Sugar Lbs	Beets Tons	Sucrose %	Beets/100' No.	Root Rot %	Missing Feet No.	RJAP %	Powdery Mildew 10/17
Mean			8162.4	25.99	15.65	194.2	5.6	1.1	85.1	3.1
LSD (.05)			1000.4	3.15	0.59	17.9	5.7	1.7	1.8	0.9
C.V. (%)			12.4	12.31	3.83	9.4	102.7	151.4	2.1	28.8
F value			25.1**	21.89**	15.08**	3.0**	1.6*	2.9**	2.8**	7.8**

TEST 8003.   PERFORMANCE OF LINES UNDER RHIZOMANIA, SALINAS, CA, 2003

(cont.)

Variety	Resist	Description	Sugar Yield Sugar Lbs	Sugar Yield Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	Missing Feet No.	RJAP %	Powdery Mildew 10/17
8003-2: Multigerm lines with Bvm germplasm										
Beta 6600	rzrz	rec'd 7-11-00,susc.ck.	4876	16.55	14.86	205	4.8	2.8	84.9	3.4
Beta 4776R	Rzl	9-2002, Betaseed	9775	30.28	16.17	199	2.0	0.0	87.1	1.8
R221	Rzl,Bvm	RZM-% R021, (C26,C27)	8863	28.12	15.79	206	3.7	0.8	85.4	3.4
US H11	rzrz	susc.check, 10/14/02	3776	14.59	13.15	216	5.7	4.1	84.5	4.8
Z210	rzrz	Inc. Z010(C), (Polish gp)	4890	14.51	16.88	189	4.2	1.0	86.7	4.8
Y167	Rzl,C51	RZM-ER-% Y967, (C67/2)	9322	29.38	15.90	200	2.5	0.4	84.1	2.4
Angelina	Rzl,Rz2	3/10/03, KWS	10148	30.56	16.65	207	2.0	0.1	87.4	1.3
Y275	Rzl,C51	RZM-% Y075	9366	29.78	15.76	200	0.9	0.0	83.6	3.1
Y277	Rzl,C51	RZM Y175, Y167,…(C)	9612	31.66	15.19	189	5.3	0.4	84.6	3.0
2921	Rzl,C51	RZM-% 0921 (A,aa)	8727	29.00	15.09	197	6.6	0.8	85.0	3.4
P227	Rzl,Bvm	PMR-RZM-NB P027(C),(CP03)	6238	19.95	15.65	190	8.4	1.4	84.7	4.0
P228	Rzl,Bvm	PMR-RZM-NB P028(C),(CP04)	7614	25.33	15.00	194	8.5	0.4	83.7	3.1
P229	Rzl,Bvm	PMR-RZM-NB P029(C),(CP05)	9558	29.89	16.00	195	6.3	0.6	85.5	1.9
P230	Rzl,Bvm	PMR-RZM-NB P030(C),(CP06)	9472	29.19	16.25	205	3.9	1.3	84.8	2.3
P207/8(Sp)	Rzl,Bvm	Inc. P007/8	9572	30.46	15.76	197	8.2	1.1	83.8	2.0
P207/8(Iso)	Rzl,Bvm	PMR-RZM-NB P007/8,(CP07)	10128	31.84	15.90	209	7.7	0.9	84.6	1.6
Mean			8246.0	26.32	15.63	199.9	5.0	1.0	85.0	2.9
LSD (.05)			946.2	3.06	0.56	16.4	5.2	1.7	2.1	0.9
C.V. (%)			11.6	11.74	3.64	8.3	103.8	169.7	2.5	29.8
F value			38.8**	32.24**	18.53**	1.8NS	1.8NS	3.3**	2.4*	12.4**

NOTES: This test under rhizomania conditions is part of a series of tests to evaluate breeding lines and germplasm under development at Salinas.   This series includes tests: 203 for bolting tendency evaluation; 2103 for virus yellows reactions; 2503 for non-rhizomania performance; 5303 for reaction to Erwinia sof rot and powdery mildew; 8303 for reaction to Cercospora leaf spot; and Beet curly top virus resistance in BSDF's Kimberly, ID nursery.   Hybrid performance of this germplasm was evaluated in a parallel set of tests.

TEST 8003. PERFORMANCE OF LINES UNDER RHIZOMANIA, SALINAS, CA, 2003

(cont.)

Variety	Resist	Description	Sugar Yield Sugar Lbs	Beets Tons	Sucrose %	Beets/100' No.	Root Rot %	Missing Feet No.	RJAP %	Powdery Mildew 10/17
8003-3:	Multigerm,	S^f,Aa populations								
Eagle	Rz1	9-16-02, Holly Hybrids	8057	25.66	15.76	158	4.5	3.3	85.1	4.4
Beta 4430R	Rz1	9-2002, Betaseed	9799	30.32	16.17	202	4.4	0.4	87.3	3.0
2931	Rz1	RZM-% 0931(A,aa)	8155	25.98	15.70	202	8.9	1.8	83.8	2.5
2941	Rz1	RZM-% 0941(A,aa)	8531	27.89	15.31	198	3.4	0.5	84.3	3.0
Z225	Rz1	RZM-% Z025(A,aa)	8234	25.71	15.96	199	5.8	1.5	84.8	3.9
CR211	Rz1	RZM-% CR011(A,aa)	9408	30.74	15.30	197	2.3	0.3	84.4	3.6
2933	Rz1	RZM-% 9933(A,aa)	7974	26.93	14.82	197	7.2	1.5	84.6	3.5
2942	Rz1	RZM-% 0942(A,aa)	6950	21.54	16.20	191	7.0	2.3	83.8	2.4
2943(C)	Rz1	MM,S^f,Aa,%S(C)aa x A	9743	30.21	16.14	186	3.0	0.6	85.9	2.3
CR214	Rz1	Inc. 1241,2,3(C),(Aa)	7406	24.84	15.00	184	2.4	0.9	85.5	3.0
N224	Rz1,Bp	RZM-NR N124(A,aa)	7969	27.49	14.56	190	5.5	1.9	83.1	2.8
R278H23	Rz1	Z025-9aa x RZM R178,(C78/3)	9825	29.62	16.59	189	5.3	1.1	85.2	2.4
R278H41	Rz1	RZM 1941aa x RZM R178	9289	29.08	15.99	199	8.1	1.5	85.5	3.4
Y291H41	Rz1,C51	RZM 1941aa x RZM Y191	9078	28.58	15.86	187	7.8	0.4	85.4	4.0
Y291H23	Rz1,C51	C025-9aa x RZM Y191	9738	29.20	16.70	197	5.3	0.3	84.6	3.3
Y291H5	Rz1Rz1,C51	C833-5HO x RZM Y191	10269	32.04	16.06	182	5.8	0.9	84.9	3.4
Mean			8776.6	27.86	15.76	191.3	5.4	1.2	84.9	3.2
LSD (.05)			984.6	2.97	0.57	18.5	5.2	1.4	1.6	0.9
C.V. (%)			11.3	10.75	3.67	9.8	98.0	118.3	1.9	28.2
F value			8.0**	6.38**	8.88**	2.7**	1.2NS	2.9**	2.8**	3.9**

NOTES (cont.): Test 8003 was machine harvested, so individual roots were not scored for rhizomania.
Rhizomania was moderately severe. Powdery mildew was scored just prior to harvest after being controlled
earlier. Most root rot was due to Sclerotium rolfsii; missing ft of row was mostly caused by S.rolfsii rot
and where roots were unharvestable, plot weights were adjusted. Less rotted beets were weighed but not
included in sugar sample. RJAP = 100(%sugar/%soluble solids). Rust and downy mildew were mild to moderate
depending upon the entry. Rz1 = Holly resistance. C51 = resistance from WB(Bvm) thru R22 (C50,C51). Bvm =
resistance from other Beta vulgaris subspecies maritima. Bp = SBCN resistance from Beta procumbent Hs pro-1.

A55

TEST 7403. EVALUATION OF SELECTED MULTIGERM PROGENY LINES UNDER RHIZOMANIA, SALINAS, CA, 2003

48 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: April 30, 2003
Harvested: October 22, 2003

Variety		Description	Acre Yield		Sucrose %	Beets/100' No.	Root Rot %	RJAP %	Powdery Mildew 10/20
			Sugar Lbs	Beets Tons					
Checks									
Y290		RZM-% Y090	9093	28.22	16.10	198	0.0	84.3	3.8
Z210		Inc. Z010(C),Polish %S PX	6910	21.57	16.23	200	0.0	84.9	4.3
Inc. S₁ progeny lines									
Z025-9	(CZ25-9)	Z825-9aa x A	7942	24.39	16.33	209	0.0	82.3	1.8
Z225-9	(CZ25-9)	RZM Z025-9 (A,aa)	8958	27.39	16.42	180	2.2	84.5	2.0
2930-35	(C930-35)	RZM 1930-35aa x A	8293	25.80	16.05	189	0.0	83.5	3.0
0930-19	(C930-19)	8930-19aa x A	8595	27.82	15.45	202	0.0	86.7	2.8
1930-19	(C930-19)	NB 8930-19 (A,aa)	7739	26.20	14.77	209	0.0	83.7	2.8
2930-19	(C930-19)	RZM 1930-19aa x A	8660	28.38	15.20	191	0.0	84.4	2.3
1927-4	(C927-4)	RZM 9927-4aa x A	9364	31.45	14.85	211	0.0	83.4	4.0
2927-4	(C927-4)	RZM 1927-4 (A,aa)	9042	29.43	15.35	205	6.5	83.2	3.0
1924-2		RZM 9924-2aa x A	8538	26.79	15.97	189	0.0	85.3	2.5
1929-4		RZM 9929-4aa x A	8520	28.42	15.02	209	0.0	80.8	2.3
2929-45		9929-45aa x A	7959	25.80	15.32	143	0.0	87.1	2.5
2936-10		RZM 0936-10aa x A	8934	30.64	14.55	202	0.0	82.8	3.0
2936-16		0936-16aa x A	7758	23.79	16.33	211	0.0	82.3	2.5
2931-3		Inc. 0931-3 (A,aa)	9393	30.44	15.43	195	0.0	83.6	2.0
2931-20		Inc. 0931-20 (A,aa)	7055	23.18	15.20	205	0.0	85.6	2.5
2941-20		Inc. 0941-20 (A,aa)	8053	27.01	14.90	202	1.1	84.9	2.3
2933-7		Inc. 0933-7 (A,aa)	8635	28.22	15.38	223	0.0	84.0	3.3
2933-14		Inc. 0933-14 (A,aa)	6740	21.97	15.40	211	0.0	83.8	2.0
2933-17		Inc. 0933-17 (A,aa)	6641	22.15	14.83	205	0.0	83.7	3.0
CR210-2		Inc. CR910-2	9036	30.03	15.00	209	0.0	82.6	4.3
CR211-7		Inc. CR911-7	8422	29.03	14.50	200	2.2	82.0	3.3
Increase of FS progeny lines									
P207/8	(CP07)	PMR-RZM-NR P007/8	10163	32.66	15.50	211	1.1	82.1	2.0
P207/8	(Sp)	Inc P007/8	9909	31.65	15.68	214	2.5	85.2	2.0

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TEST 7403. EVALUATION OF SELECTED MULTIGERM PROGENY LINES UNDER RHIZOMANIA, SALINAS, CA, 2003
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Root Rot %	RJAP %	Powdery Mildew 10/20
Increase of FS progeny lines (cont.)								
P229-8	Inc. P029-8	8476	27.15	15.65	186	0.0	83.3	2.8
P229-20	Inc. P029-20	8235	26.95	15.35	214	9.4	82.3	2.5
P230-10	Inc. P030-10	9266	28.83	16.08	180	3.8	85.4	2.5
P230-17	Inc. P030-17	9808	31.04	15.77	207	0.0	84.7	3.0
R278-4	Inc. R078-4	8018	27.21	14.73	200	2.0	84.4	3.0
R278-2	Inc. R078-2	8714	27.21	16.00	211	0.0	84.2	3.5
R278-7	Inc. R078-7	7787	24.79	15.80	200	0.0	83.6	4.3
R278-14	Inc. R078-14	7555	22.98	16.42	205	0.0	84.2	2.5
R278-16	Inc. R078-16	10277	31.24	16.42	200	0.0	82.8	3.0
R278-27	Inc. R078-27	7230	23.42	15.50	195	0.0	84.5	3.0
R280/2-9	Inc. R080/2-9	7884	25.00	15.82	195	1.4	84.0	4.5
R280-6	Inc. R080-6	8467	25.82	16.35	155	0.0	84.7	3.3
R270-18	Inc. R080-18	8535	27.41	15.50	193	0.0	83.1	4.5
Y269-8	Inc. Y069-8	8119	25.00	16.33	191	0.0	83.0	2.0
Y269-18	Inc. Y069-18	7964	25.20	15.88	186	0.0	85.1	2.3
Y269-39	Inc. Y069-39	9312	30.44	15.30	214	0.0	84.2	1.8
Roberta	3/25/03, susc. check	6065	22.21	13.52	214	1.1	85.7	2.8
R243-14	Inc. R043-14	10909	34.47	15.88	218	0.0	85.7	2.0
Y267-21	Inc. Y067-21	9657	31.24	15.43	211	0.0	82.0	2.8
Y267-24	Inc. Y067-24	8557	28.83	14.77	182	0.0	83.5	1.5
Y267-34	Inc. Y067-34	8673	29.03	14.85	198	0.0	82.4	2.5
Y271-14	Inc. Y071-14	8327	27.62	15.05	161	0.0	82.1	3.8
Y275-16	Inc. Y075-16	7885	25.60	15.45	216	0.0	84.5	4.5
Mean		8459.8	27.32	15.49	199.0	0.7	83.9	2.9
LSD (.05)		2352.1	7.47	0.78	29.3	4.1	2.3	0.9
C.V. (%)		19.9	19.57	3.62	10.5	422.8	1.9	23.3
F value		1.3NS	1.30NS	4.90**	2.3**	1.5NS	2.6**	5.8**

Notes: Test 7403 evaluates full-sib and S₁ progeny line increases following FS and S₁ progeny tests per se. Also see tests 303 for bolting tendency, 2403 and 2803 for relative performance under virus yellows, 3203 under non-rhizomania and 5403 under Erwinia. Also see hybrid performance of these lines in tests 403,2903,3003,8103 & 8203. A,aa = plants increased in bulk; aa x A = increase thru genetic-male-sterile plants.

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TEST 6403-1. EVALUATION OF LINES FOR RESISTANCE TO PM, SBCN, RHIZOMANIA & PERFORMANCE, SALINAS, CA, 2003

64 entries x 3 reps., sequential
1-row plots, 11 ft. long

Planted: April 30, 2003
Harvested: November 13, 2003

Variety	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	Root Rot %	Bolting %	RJAP %	Powdery Mildew Mean	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)	Rhizomania Without SBCN %	Galls %
Checks for PMR													
US H11 (susc ck)	3992	14.00	14.33	25	23	0.0	0.0	85.5	4.4	4.8	29.0	48.0	
01-C37 (susc ck)	4371	13.58	16.07	24	23	0.0	0.0	82.6	3.7	4.0	58.7	68.6	
02-WB97 (SB x WB)	2055	7.36	14.03	20	20	0.0	33.0	80.1	1.4	4.9	30.3	84.1	
02-WB242(SB x WB)	2563	8.91	14.30	22	19	3.1	27.9	76.5	1.9	4.7	41.6	75.9	
Angelina (2003)	11036	31.40	17.57	22	21	0.0	0.0	84.6	2.6	2.9	98.2	65.1	
Beta 4001R (2003)	10887	31.40	17.27	23	23	0.0	0.0	86.1	1.6	2.9	97.3	75.9	
Beta 4430R (2003)	11064	32.82	16.67	25	24	0.0	0.0	85.7	2.7	2.7	100.0	57.9	
02-WB242(gh) Bvm	286	1.05	13.50	17	11	1.6	90.6	81.8	0.7	3.3	86.1	94.4	
Lines with PMR													
N112 (WB242)	10372	30.55	16.97	20	19	0.0	0.0	84.8	1.8	3.0	94.7	75.2	
R039 (C39R)	7570	22.07	17.07	20	19	0.0	0.0	83.4	1.8	3.2	89.5	52.0	
R278 (C78/3)	8265	24.33	17.07	17	17	0.0	0.0	84.5	2.2	3.3	92.5	49.4	
8918-12	8791	25.79	17.00	20	17	0.0	0.0	83.6	0.6	3.2	94.2	66.4	
P207/8 (Sp)	9703	28.57	16.93	21	19	0.0	0.0	83.7	1.6	3.3	89.3	63.4	
P207/8 (CP07)	10789	30.55	17.63	22	21	0.0	0.0	83.6	1.0	3.1	96.9	45.5	
01-C37 (susc ck)	4459	13.44	16.70	23	22	0.0	0.0	84.0	4.4	4.1	57.0	48.3	
P601 (WB97 & 242)	6975	20.51	17.07	25	22	0.0	0.0	85.2	2.3	4.3	52.9	71.0	
P127	4815	14.29	16.87	23	21	0.0	1.4	82.4	3.7	4.1	55.3	54.6	
P227 (CP03)	5710	17.27	16.60	22	19	0.0	4.0	83.2	3.2	3.7	79.8	48.3	
P128	8302	25.62	16.20	22	21	3.0	0.0	81.8	2.6	3.5	82.7	52.8	
P228 (CP04)	7147	22.07	16.13	23	22	0.0	0.0	81.9	1.9	3.6	80.0	56.6	
P129	9154	26.31	17.47	22	21	0.0	0.0	83.4	1.7	3.4	86.7	60.9	
P229 (CP05)	10047	28.81	17.53	19	19	0.0	0.0	84.5	0.9	3.6	80.5	47.8	
P130	9405	27.60	17.10	21	20	1.8	0.0	82.7	2.1	3.3	93.3	34.1	
P230 (CP06)	9939	27.58	18.03	22	22	0.0	0.0	83.5	2.1	3.3	91.1	60.2	

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TEST 6403-1. EVALUATION OF LINES FOR RESISTANCE TO PM, SBCN, RHIZOMANIA & PERFORMANCE, SALINAS, CA, 2003

(cont.)

Variety	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	Root Rot %	Bolting %	RJAP %	Powdery Mildew Mean	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)	Without SBCN %	Galls %
Lines with PMR (cont.)													
P229-8	6498	18.25	17.87	22	20	0.0	0.0	83.5	1.7	3.6	77.4	70.0	
P229-20	7643	21.92	17.43	22	22	0.0	0.0	83.2	2.0	3.9	65.0	34.4	
P230-10	8177	23.30	17.57	22	20	0.0	0.0	82.9	1.4	3.1	89.2	50.1	
P230-17	9370	26.59	17.67	24	21	0.0	0.0	83.1	3.0	3.0	98.6	82.8	
Y275	9142	26.31	17.40	23	21	0.0	0.0	84.9	2.4	3.3	90.3	65.6	
Angelina (2002)	9271	25.45	18.27	21	21	1.6	0.0	85.4	5.2	3.0	100.0	79.9	
R278 (C78/3)	7881	23.69	16.67	17	16	0.0	0.0	81.6	2.9	3.7	78.4	36.0	
US H11 (susc ck)	3875	13.66	14.13	24	22	0.0	0.0	83.4	3.9	5.2	22.8	27.8	
Multigerm Lines with SBCNR													
N172 (*Bvm*)	7699	24.47	15.77	20	19	0.0	0.0	80.9	2.7	3.9	69.0	84.1	
R278H95 (*Hs*)	7926	24.56	16.17	20	19	1.8	0.0	84.2	2.6	3.3	88.1	63.3	25.2
R278H96 (*Hs*)	8480	25.04	16.97	20	20	0.0	0.0	88.0	2.8	3.2	93.3	31.9	1.7
R278H97 (*Hs*)	10428	29.62	17.63	20	20	0.0	0.0	83.7	2.0	3.3	91.7	66.2	1.6
N224H98 (*Hs*)	8571	26.73	16.03	20	17	0.0	0.0	83.5	1.9	3.4	82.1	78.3	32.9
N224(C)H94 (*Hs*)	8187	26.03	15.83	20	19	0.0	0.0	83.9	2.7	3.2	97.1	81.9	34.7
N224 (*Hs*)	8271	26.59	15.57	21	18	0.0	0.0	80.8	1.8	3.1	92.5	78.9	42.1
N224(C) (*Hs*)	6974	22.21	15.70	23	22	0.0	0.0	82.4	2.8	3.3	89.2	67.5	34.0
N224 -1 S$_2$	4371	16.27	13.57	20	20	0.0	0.0	78.0	2.0	3.3	95.2	83.2	54.9
-2 S$_2$	6665	20.93	16.03	17	17	1.6	0.0	82.1	2.6	3.5	87.0	91.7	20.9
-3 S$_2$	4678	16.39	14.23	19	18	0.0	0.0	81.1	2.0	2.9	97.8	68.3	45.2
-4 S$_2$	6474	21.56	14.90	17	16	2.2	0.0	81.2	1.7	3.7	80.2	72.5	21.2
-5 S$_2$	4028	11.37	17.63	18	17	1.6	0.0	78.9	4.3	3.1	97.9	87.7	43.3
-6 S$_2$	6347	20.23	15.67	18	18	0.0	0.0	76.3	1.9	3.0	100.0	100.0	47.2
-7 S$_2$	6053	18.74	16.20	21	20	1.4	0.0	83.2	1.7	3.4	90.2	67.5	43.6
-8 S$_2$	5336	15.46	17.27	17	17	0.0	0.0	80.0	4.3	3.1	98.0	80.9	28.0
N230 -05-1 S$_n$	4866	14.29	16.83	16	13	0.0	0.0	80.3	3.0	4.0	76.2	54.5	0.0
-05-2 S$_n$	6126	17.97	17.03	14	13	0.0	0.0	79.7	1.9	4.1	75.7	45.9	0.0

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TEST 6403-1. EVALUATION OF LINES FOR RESISTANCE TO PM, SBCN, RHIZOMANIA & PERFORMANCE, SALINAS, CA, 2003

(cont.)

Variety	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	Root Rot %	Bolting %	RJAP %	Powdery Mildew Mean	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)	Without SBCN %	Galls %
Multigerm Lines with SBCNR (cont.)													
N230-05-3 S_n	5258	15.44	17.10	16	13	0.0	0.0	81.3	2.6	3.9	75.0	37.5	0.0
-05-4 S_n	5912	16.61	17.87	18	16	0.0	0.0	77.6	2.3	4.1	70.0	18.8	0.0
Monogerm lines with SBCNR													
N265-31 *HsHs*	539	4.51	6.17	13	11	0.0	0.0	49.9	1.4	4.4	49.3	100.0	100.0
N265-31HOM *Hs*	6441	24.03	13.47	13	12	0.0	0.0	81.5	2.8	3.1	97.2	100.0	91.4
N265-9HOM *Hs*	5651	22.98	12.40	12	14	0.0	0.0	81.1	2.1	3.1	97.9	84.4	55.7
N265-9 *HsHs*	3363	14.00	12.03	18	17	0.0	0.0	77.8	1.8	3.5	89.6	85.4	85.4
N265 *Hs*	7071	23.38	15.20	21	20	0.0	0.0	83.7	3.0	3.4	86.5	73.4	51.0
N265HO *Hs*	7117	23.62	15.07	19	17	0.0	0.0	83.9	3.1	3.3	89.5	85.8	59.3
N267HO *Hs*	8700	27.87	15.77	21	20	0.0	0.0	80.6	2.0	3.1	98.4	58.9	44.7
N267 *Hs*	8442	26.17	16.13	22	20	0.0	0.0	83.8	1.4	3.4	84.4	61.8	35.8
N265(C) *Hs*	6285	23.35	13.67	18	17	0.0	0.0	81.2	2.1	3.4	82.2	84.9	59.8
N265(C)HOM *Hs*	6975	25.94	13.33	10	10	0.0	0.0	80.3	2.9	3.4	87.9	72.3	62.8
N269-11 *Hs*	9245	25.32	18.27	21	19	0.0	0.0	82.9	4.4	3.0	100.0	44.7	13.9
N269-12 *Hs*	9536	27.16	17.57	23	22	0.0	0.0	84.3	3.9	3.0	100.0	68.7	17.0
Mean	7055.8	21.62	16.03	20.1	18.7	0.3	2.5	82.0	2.4	3.5	82.6	71.0	37.2
LSD (.05)	1748.1	4.91	1.39	3.2	3.9	2.1	4.2	5.1	1.0	0.5	19.1	34.1	18.0
C.V. (%)	15.3	14.06	5.36	10.0	12.8	419.4	106.5	3.8	24.3	8.9	14.3	29.4	29.6
F value	16.0**	14.94***	15.52**	7.3**	5.2**	1.0NS	67.9**	6.7**	8.3**	8.5**	7.3**	2.8**	18.1**

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NOTES: See tests 5203, 6503, et al. for entry descriptions. Hand harvested. N112 from WB242. Counts for SBCN cysts confounded by reaction to rhizomania; rhizomania susceptible roots easier to evaluate for cysts than resistant roots due to greater proliferation of feeder roots. Powdery mildew score 9/8, 9/18, & 11/11/03. Rhizomania score 0 to 9 where 9 = dead; %R = scores 1-4/total. Rhizomania moderate. At harvest, individual roots were examined for white cysts of sugar beet cyst nematode. Roots were divided into two classes: without(w/o) visible SBCN and with(w/) SBCN. Only root with no visible cysts were counted as w/o. For entries 34-64, roots with (w/) and without(w/o) galls were counted. Galls refers to the trait associated with resistance to SBCN (*Hs pro-1*) from *Beta procumbens*.

Planted: April 30, 2003
Harvested: November 12, 2003

64 entries x 3 reps, sequential
1-row plots, 22 ft. long

Variety	Description	Acre Yield			Stand Count No.	Harv Count No.	Root Rot %	Bolting %	RJAP %	Powdery Mildew Mean	Rhizomania Resistance		Without SBCN %
		Sugar Lbs	Beets Tons	Sucrose %							DI	%R(0-4)	
Checks													
US H11	susc. check,10/4/02	3789	14.43	13.10	22	20	2.9	0.0	83.8	3.9	4.9	22.0	54.6
P207/8	RZM-PMR-NR P007/8	9868	28.57	17.20	20	19	0.0	0.0	82.9	1.3	3.3	91.5	88.5
N112	NR-RZM P912 (A,aa)	8872	26.59	16.73	21	20	0.0	0.0	86.1	2.1	3.2	96.5	90.0
N172	NR-RZM N972 (A,aa)	8595	26.73	16.07	23	23	0.0	1.3	83.2	3.2	3.4	86.7	97.1
S_n of line N12 (P912), WB242 resistance source													
N212- 1	N112-#(C)⊗,(=P912⊗)	5451	17.68	15.37	20	18	0.0	0.0	85.5	2.4	4.3	55.1	93.3
- 2		7637	24.22	15.50	17	16	0.0	0.0	82.0	1.3	3.4	86.7	100.0
- 3		7418	22.09	16.83	20	20	0.0	0.0	83.3	2.3	4.0	66.3	76.8
- 4		3750	11.39	16.50	19	17	0.0	0.0	78.0	0.8	3.7	82.5	94.2
- 5		3488	10.04	17.23	16	15	0.0	0.0	87.7	0.4	4.4	45.0	67.8
- 6		2159	6.93	15.53	19	17	0.0	0.0	85.2	3.0	4.8	28.0	96.5
- 7		6017	19.24	15.63	20	18	0.0	0.0	82.1	1.9	4.2	50.0	83.4
- 8		6779	20.37	16.67	20	19	0.0	0.0	85.9	2.7	3.8	78.0	88.9
- 9		4652	14.43	16.03	20	17	0.0	0.0	79.1	1.0	3.6	86.6	63.5
-10		9220	26.08	17.67	21	21	0.0	0.0	81.8	1.0	3.4	95.4	89.7
-11		6461	18.39	17.53	21	19	0.0	0.0	77.8	1.1	3.5	96.1	98.2
-12		5828	15.98	18.43	20	20	0.0	0.0	86.4	3.4	3.5	87.9	86.5
-13		2784	8.63	16.03	21	20	0.0	0.0	79.8	0.4	4.6	34.4	23.8
-14		1826	7.22	12.23	18	17	0.0	0.0	63.5	0.2	4.7	22.1	47.9
-15		4620	13.42	17.10	17	18	0.0	0.0	81.5	0.1	4.5	47.3	54.8
-16		2940	9.76	15.00	18	17	0.0	0.0	74.5	0.6	4.1	67.1	93.8
-17		8382	26.80	15.77	17	17	0.0	0.0	81.3	0.4	2.8	98.7	66.7
-18		4918	15.09	16.30	16	15	0.0	0.0	81.5	0.7	4.6	34.4	55.3
-19		5621	15.56	18.17	17	16	0.0	0.0	83.8	2.2	3.7	83.4	82.1
-20		4584	14.44	16.00	18	17	0.0	0.0	81.7	0.4	4.5	45.6	80.0

TEST 6503. EVALUATION OF PROGENY LINES FROM POPNS-N12 and -N72 FOR RESISTANCE TO PM, SBCN, & RHIZOMANIA, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	Root Rot %	Bolting %	RJAP %	Powdery Mildew Mean	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)	Rhizomania Without SBCN %
S_n of line N12 (P912), WB242 resistance source (cont.)													
N212-21	N112-#(C)⊗	7942	23.62	16.90	20	19	0.0	0.0	83.0	1.0	3.8	78.5	73.1
-22		4986	14.03	17.80	15	15	0.0	0.0	80.4	0.8	3.5	93.0	97.4
-23		4964	15.14	16.40	19	16	0.0	0.0	84.1	1.9	4.6	38.1	78.8
-24		6715	19.38	17.37	17	17	0.0	0.0	83.1	1.3	4.2	59.5	64.3
2927-4	RZM 1927-4,(C924-4)	6641	21.78	15.40	21	18	0.0	0.0	80.2	2.9	3.7	68.8	100.0
P207/8	RZM-PMR-NR P007/8	9974	29.42	17.03	19	18	3.5	0.0	81.8	1.0	3.3	91.1	92.6
US H11	susc. check	2622	9.76	13.40	24	19	0.0	0.0	81.3	3.9	5.3	12.6	49.8
P230	PMR-RZM-NRP030-#(C)	9081	26.59	17.13	23	22	0.0	0.0	84.1	1.2	3.5	91.3	70.7
N212-201	RZM-PMR N112⊗	8090	25.18	16.13	19	19	0.0	0.0	79.6	1.6	3.3	89.8	90.5
-202		9105	28.36	16.13	17	14	0.0	0.0	82.8	1.9	3.8	69.6	100.0
-203		8503	25.70	16.57	19	20	0.0	0.0	83.1	0.2	3.6	78.2	92.1
-204		7727	23.71	16.33	21	20	0.0	0.0	83.2	1.0	3.6	74.3	93.4
-205		6544	18.11	18.07	17	18	0.0	0.0	80.8	1.4	3.6	81.4	100.0
-206		8836	27.87	15.90	18	18	0.0	0.0	85.2	2.6	3.5	73.8	87.3
-207		10301	30.84	16.67	17	16	2.2	0.0	83.5	1.6	3.8	75.6	72.7
-208		9330	30.81	15.10	3	3	0.0	0.0	80.6	1.2	3.7	77.8	66.7
S_n of line N72, KWS-Bvm resistance source													
N272-1	N172-#(C)⊗	6050	20.61	14.70	15	12	21.7	0.0	77.4	3.9	3.7	79.7	92.5
-2		4271	14.13	15.10	19	15	5.1	0.0	82.2	3.1	4.0	63.9	96.0
-3		617	5.36	5.70	17	12	1.8	4.8	43.0	1.0	4.4	39.1	61.0
-4		580	6.08	4.77	19	18	0.0	44.2	43.3	0.9	3.7	70.1	68.1
-5		571	3.39	9.13	16	13	10.9	40.8	62.1	0.8	4.4	44.5	87.4
-6		5602	17.02	16.40	18	14	17.4	0.0	81.5	3.6	3.5	93.8	97.6
-7		5179	17.40	14.77	18	15	3.8	0.0	81.1	4.0	3.5	88.9	72.5
-8		1273	6.43	9.13	16	9	2.1	0.0	70.0	1.1	4.6	32.4	55.6
-9		6818	24.71	13.80	17	15	0.0	0.0	78.4	3.7	3.4	85.1	83.6
-10		-.-	-.-	-.-	--	--	-.-	-.-	-.-	-.-	-.-	-.-	-.-

TEST 6503. EVALUATION OF PROGENY LINES FROM POPNS-N12 and -N72 FOR RESISTANCE TO PM, SBCN, & RHIZOMANIA, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	Root Rot %	Bolting %	RJAP %	Powdery Mildew Mean	Rhizomania Resistance DI	%R(0-4)	Without SBCN %
Sₙ of line N72, KWS-*Bvm* resistance source (cont.)													
N272-221	RZM N172⊗	8242	29.56	13.93	20	19	0.0	0.0	79.3	2.2	3.2	91.1	98.3
-222		6534	19.80	16.47	22	22	0.0	0.0	81.0	1.7	3.5	88.1	68.3
-223		2422	9.00	13.23	21	18	0.0	0.0	78.1	2.1	4.4	47.7	84.2
-224		3772	12.25	15.20	18	17	0.0	0.0	80.2	2.9	3.9	70.2	55.7
-225		7183	21.92	16.37	23	22	3.1	0.0	82.0	2.1	3.9	71.0	77.3
-226		9720	28.57	17.00	22	20	0.0	0.0	83.9	2.4	3.7	80.7	92.1
-227		8449	27.30	15.50	22	22	1.7	0.0	80.3	3.6	3.1	95.2	81.2
-228		3663	12.84	14.23	22	20	1.5	0.0	82.4	4.7	3.8	67.9	91.5
Sₙ's from N72													
N272-229	RZM N172⊗	2044	8.06	12.23	18	15	0.0	0.0	66.7	3.4	4.1	60.8	70.0
-230		5242	17.26	15.07	20	18	2.9	0.0	77.6	2.6	3.3	92.7	98.1
-231		10054	32.53	15.50	21	21	0.0	0.0	78.6	1.6	3.1	98.1	89.2
-232		2289	7.97	13.20	15	12	7.1	0.0	64.6	1.7	3.7	86.2	86.5
-233		8931	28.60	15.73	20	19	0.0	0.0	81.9	3.3	3.1	96.4	98.1
-234		6478	19.60	16.53	22	19	1.3	0.0	79.9	4.2	3.4	89.9	98.2
Mean		5920.7	18.65	15.31	18.9	17.4	1.4	1.5	79.2	2.0	3.8	71.0	81.0
LSD (.05)		1679.8	5.08	2.02	4.0	4.7	9.0	7.1	7.8	0.9	0.5	22.9	31.4
C.V. (%)		17.6	16.85	8.16	13.0	16.8	393.9	305.6	6.1	27.1	8.5	19.9	24.0
F value		20.2**	18.51**	12.84**	4.5**	3.9**	1.4NS	8.7**	9.1**	15.1**	7.8**	7.7**	2.2**

NOTE: See testes 6403-1 and 5203. Also Imperial Valley tests B603, B703, and B1003 for performance under high temperature/severe rhizomania. Moderate rhizomania. Rhizomania scored on a scale of 0 to 9 where 0-4 considered resistant. PM scored 0 to 9 on 9/8, 9/18, & 11/10/03. Hand harvested. RJAP = 100(%sucrose/% soluble solids). At harvest, individual roots were examined for white cysts of sugar beet cyst nematode. Roots were divided into two classes: without(w/o) visible SBCN and with(w/) SBCN. Only root with no visible cysts were counted as w/o. SBCN infestation was variable. Scoring was difficult and imprecise, but may show trends.

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TEST 3503. EVALUATION OF MONOGERM LINES AND POPULATIONS, SALINAS, CA, 2003

48 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: March 5, 2003
Harvested: October 6, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/08	Powdery Mildew Mean	Root Rot %
Checks									
2833-5,C833-5	RZM,T-O 1833-5-#(C)mmaa x A	12003	36.69	16.38	125	82.4	0.0	4.9	0.0
99-790-68	Inc. U88-790-68	10565	34.67	15.20	139	82.3	0.0	2.5	0.0
02-C790-15	Inc. 00-C790-15	12492	43.14	14.52	143	83.5	0.5	3.9	0.0
02-C790-15CMS	99-C790-68CMS x 00-C790-15	17453	58.26	14.98	139	83.4	0.0	3.4	0.0
0546	Inc. 97-C546, (C546)	9260	35.07	13.27	143	82.1	0.3	4.1	0.0
0562	Inc. 97-C562, (C562)	9277	37.09	12.45	139	83.4	0.3	4.4	0.0
2833-5NB	NB-RZM-% 0833-5(Sp)(A,aa)	12852	39.51	16.25	136	82.7	0.3	5.1	0.0
2833-5HONB	1833-5HO x " "	12312	36.89	16.70	139	83.4	0.0	5.1	0.0
FC monogerm lines									
02-FC1015	RZM 01-FC1014H7	13493	40.52	16.65	134	83.7	0.3	5.0	0.0
02-FC1015HO	RZM 01-FC1014H5 x " "	14602	45.56	16.08	141	83.1	0.0	5.3	0.0
02-FC124	RZM 01-FC123H7	13559	43.27	15.63	132	82.5	0.0	5.0	0.0
02-FC124HO	RZM 01-FC123H5 x " "	14796	47.57	15.53	141	84.2	0.3	4.0	0.0
Monogerm lines, CMS's, and F₁CMS's									
2833-5,C833-5	RZM,T-O 1833-5-#(C)mmaa x A	12488	38.30	16.30	120	83.1	0.3	3.8	0.0
2833-5HO(Sp)	1833-5HO x " "	13454	41.04	16.40	134	83.2	0.3	4.1	0.0
2869-15	Inc. 0869-15	9291	30.84	15.00	143	84.0	1.3	3.9	0.0
2869-15H5	1833-5HO x 0869-15	15280	47.17	16.23	127	84.0	1.3	4.5	0.0
2840-9H5	1833-5HO x 0840-9	14118	47.07	14.98	132	81.9	0.5	4.6	0.0
2840-9	Inc. 0849-9	8718	35.19	12.33	123	82.2	0.3	4.1	0.0
2835-8	Inc. 9835-8	9152	31.04	14.82	141	82.5	0.0	5.8	0.0
2835-8H5	1833-5HO x 9835-8	14246	43.94	16.23	123	82.6	0.5	5.9	0.0
2835-10H5	1833-5HO x 9835-10	15236	48.18	15.77	139	82.5	0.0	4.4	0.0
2835-10	Inc. 9835-10	10646	35.68	14.82	143	80.0	0.0	4.6	0.0
2835-24	Inc. 9835-24	9681	35.68	13.57	145	81.3	0.3	3.3	1.7
2835-24H5	1833-5HO x 9835-24	13933	44.47	15.65	84	82.6	0.0	4.1	0.0
2836-13H5	1833-5HO x 9836-13	16425	52.39	15.82	136	81.7	0.0	4.6	0.0
2836-13	Inc. 9836-13	12578	39.91	15.60	139	81.3	0.5	2.5	0.0

TEST 3503. EVALUATION OF MONOGERM LINES AND POPULATIONS, SALINAS, CA, 2003
(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/08	Powdery Mildew Mean	Root Rot %
Monogerm lines, CMS's, and F₁CMS's (cont.)									
2810-19	Inc. 2810-19	9256	32.23	14.30	130	81.0	0.0	4.6	0.0
2810-19H5	1833-5HO x 2810-19	13470	43.74	15.38	132	83.4	0.3	5.0	0.0
2810-17H5	1833-5HO x 2810-17	15615	47.97	16.27	130	83.1	0.5	2.5	0.0
2810-17	Inc. 9810-17	13053	41.91	15.57	148	84.1	0.5	1.9	2.9
2848-1	Inc. 9848-1	10171	34.07	15.03	143	81.2	0.0	6.0	1.5
2848-1H5	1833-5HO x 9848-1	15473	50.48	15.30	125	82.5	0.0	5.8	0.0
Nematode resistant monogerms									
N265-31HOM	N165-9HO(g) x N165-31(g)	7924	34.10	11.63	109	82.5	0.0	4.5	0.0
N265-9HOM	N165-9HO(g) x RZM N165-9(g)	7174	34.67	10.35	118	80.1	1.3	3.4	0.0
N265	RZM-NR N165	8958	36.49	12.23	136	81.2	0.5	3.5	1.7
N267	RZM-NR N167	9707	37.69	12.80	139	82.3	0.5	2.4	0.0
N265(C)	Inc. N165-#(C)mm(g)	6330	30.64	10.57	136	76.8	0.3	3.3	0.0
N224	RZM-NR N124	11916	46.16	12.93	139	79.0	1.0	3.0	1.7
N224H98	N165-9H50(g) x RZM-NR N124	13058	47.97	13.57	139	81.7	1.0	3.6	0.0
N224(C)H94	N165-9HO(g) x N124-#(C)(g)	9608	36.89	12.75	127	83.7	0.3	3.9	0.0
Monogerm populations									
2835	RZM,T-O 1835-#mmaa x A	12331	45.92	13.40	127	80.6	0.0	4.5	0.0
2836	RZM,T-O 1836-#mmaa x A	11191	40.52	13.73	130	83.3	0.0	5.4	0.0
2837	RZM,T-O 1836H7-#(C)mmaa x A	12835	43.17	14.90	109	82.4	0.0	5.5	0.0
2842, (C842)	RZM 1842mmaa x A	13628	46.36	14.68	127	83.0	0.0	4.9	0.0
2848	RZM,T-O 1848-#(C)mmaa x A	11880	37.25	15.97	114	83.3	0.3	4.8	0.0
2790, (C790)	0790mmaa x A	14132	52.81	13.40	141	80.4	0.0	5.0	0.0
2843	RZM-% 0841H7 (A,aa)	12863	41.63	15.40	136	81.8	0.3	4.5	0.0
2846	RZM-% 0841H69 (A,aa)	10758	38.30	14.15	114	81.2	0.3	5.1	0.0
Mean		12067.5	41.04	14.61	131.8	82.3	0.3	4.3	0.2
LSD (.05)		2431.4	7.34	1.35	18.4	3.1	0.9	0.8	1.8
C.V. (%)		14.4	12.79	6.61	10.0	2.7	232.8	14.0	645.7
F value		8.5**	5.83**	10.90**	3.2**	1.7*	1.2NS	10.8**	0.9NS

Note: See test 7303 for performance under rhizomania.

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TEST 7303. EVALUATION OF MONOGERM LINES AND POPULATIONS UNDER RHIZOMANIA, SALINAS, CA, 2003

48 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: April 30, 2003
Harvested: October 22, 2003

Variety	Description	Acre Yield Sugar Lbs	Beets Tons	Sucrose %	Beets/100' No.	Root Rot %	RJAP %	Powdery Mildew 10/20
Checks								
2833-5(Sp)	RZM,T-O 1833-5-#(C)mmaa x A	7981	24.25	16.45	186	0.0	85.4	4.0
99-790-68	Inc. U88-790-68	3215	11.29	14.25	191	0.0	85.5	3.0
02-C790-15	Inc. 00-C790-15	4996	17.13	14.57	205	0.0	85.6	2.3
02-C790-15CMS	99-C790-68CMS x 00-C790-15	6116	20.36	15.00	195	0.0	85.4	3.8
0546	Inc. 970C546, (C546)	2616	9.21	14.13	200	0.0	82.4	4.0
0562	Inc. 97-C562, (C562)	2121	7.31	14.70	195	0.0	83.7	3.3
2833-5NB	NB-RZM-% 0833-5(Sp)(A,aa)	7000	21.37	16.38	214	0.0	83.3	4.0
2833-5HONB	1833-5HO x " "	6637	20.48	16.35	193	0.0	83.5	4.0
FC monogerm lines								
02-FC1015	RZM 01-FC1014H7	7872	24.35	16.17	198	0.0	83.8	3.5
02-FC1015HO	RZM 01-FC1014H5 x "	8092	25.40	16.08	193	0.0	83.5	4.3
02-FC124	RZM 01-FC123H7 "	6336	19.79	15.97	184	0.0	85.2	4.3
02-FC124HO	RZM 01-FC123H5 x "	9068	28.38	16.00	193	0.0	83.6	4.5
Monogerm lines, CMS's and F₁CMS's								
2833-5(Sp)	RZM,T-O 1833-5-#(C)mmaa x A	6977	21.77	16.08	193	0.0	85.6	3.8
2833-5HO(Sp)	C833-5HO x " "	6478	21.64	15.20	209	0.0	82.3	3.5
2869-15	Inc. 0869-15	934	3.31	14.10	116	0.0	83.9	0.8
2869-15H5	C833-5HO x 0869-15	10249	31.45	16.27	184	0.0	86.6	4.0
2840-9H5	C833-5HO x 0840-9	9677	32.05	15.10	184	0.0	83.5	4.3
2840-9	Inc. 0840-9	3896	13.89	13.88	175	0.0	82.9	3.3
2835-8	Inc. 9835-8	3659	12.78	14.30	225	1.0	78.3	4.3
2835-8H5	C833-5HO x 9835-8	8105	25.34	16.00	180	0.0	84.1	5.3
2835-10H5	C833-5HO x 9835-10	10059	31.45	15.98	175	0.0	86.4	3.3
2835-10	Inc. 9835-10	4626	14.01	16.60	216	0.0	84.3	3.0
2835-24	Inc. 9835-24	6194	21.91	14.07	191	0.0	81.7	3.3
2835-24H5	C833-5HO x 9835-24	10263	32.56	15.72	136	0.0	85.2	3.5
2836-13H5	C833-5HO X 9836-13	11208	35.48	15.80	189	0.0	85.6	3.8
2836-13	Inc. 9836-13	6345	20.84	15.23	175	0.0	82.3	3.5

TEST 7303. EVALUATION OF MONOGERM LINES AND POPULATIONS UNDER RHIZOMANIA, SALINAS, CA, 2003
(cont.)

Variety	Description	Acre Yield		Sucrose %	Beets/ 100' No.	Root Rot %	RJAP %	Powdery Mildew 10/20
		Sugar Lbs	Beets Tons					
Monogerm lines, CMS's and F₁CMS's (cont.)								
2810-19	Inc. 2810-19	5523	18.91	14.60	198	0.0	82.7	5.0
2810-19H5	C833-5HO x 2810-19	9430	29.77	15.85	166	0.0	85.3	4.8
2810-17H5	C833-5HO x 2810-17	9924	32.05	15.43	168	0.0	84.9	2.5
2810-17	Inc. 9810-17	6043	22.11	13.77	202	3.4	82.8	1.5
2848-1	Inc. 9848-1	4822	16.73	14.43	202	0.0	83.3	6.0
2848-1H5	C833-5HO X 9848-1	9392	29.95	15.68	152	0.0	86.1	5.5
Nematode resistant monogerms (B.procumbens)								
N265-31HOM	N165-9HO(g) x N165-31(g)	7355	27.88	13.20	143	0.0	83.4	3.0
N265-9HOM	N165-9HO(g) x RZM N165-9(g)	8612	33.43	12.95	166	0.0	82.5	2.3
N265	RZM-NR N165	4532	17.38	12.95	184	1.3	81.4	3.0
N267	RZM-NR N167	7557	25.80	14.65	202	0.0	83.5	2.5
N265(C)	Inc. N165-#(C)mm(g)	6345	25.10	12.65	177	0.0	82.2	3.3
N224	RZM-NR N124	8731	31.04	14.10	195	0.0	83.9	2.8
N224H98	N165-9H50(g) x RZM-NR N124	10002	33.86	14.77	186	0.0	84.6	3.3
N224(C)H94	N165-9HO(g) x N124-#(C)(g)	9225	31.06	14.88	182	0.0.	86.3	3.0
Monogerm populations								
2835	RZM,T-O 1835-#mmaa x A	9385	31.16	15.05	191	0.0	85.3	4.3
2836	RZM,T-O 1836-#mmaa x A	7259	26.20	13.95	195	0.0	82.8	4.0
2837	RZM,T-O 1836H7-#(C)mm	7148	23.26	15.32	173	0.0	84.5	4.5
2842	RZM 1842mmaa x A, (C842)	7317	25.16	14.55	193	0.0	82.6	4.8
2848	RZM,T-O 1848-#(C)mmaa x A	8847	28.00	15.77	198	0.0	85.5	4.8
2790	0790mmaa x A	5401	18.18	14.80	191	0.0	85.7	4.5
2843	RZM-% 0841H7(A,aa)	4937	15.84	15.60	177	0.0	81.8	3.5
2846	RZM-% 0841H69(A,aa)	6685	22.15	15.05	207	0.0	83.1	4.0
Mean		6983.1	23.18	15.01	186.4	0.1	83.9	3.7
LSD (.05)		1760.1	5.80	1.09	27.9	1.1	2.8	1.1
C.V. (%)		18.0	17.88	5.18	10.7	669.2	2.3	21.5
F value		14.1**	13.13**	6.74**	4.0**	1.8**	2.7**	6.2**

Notes: Also see tests 203 for bolting tendency, 3503 for non-rhizomania performance, and 5303 for reaction to Erwinia and powdery mildew.

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TEST 2603. PERFORMANCE OF COMMERCIAL HYBRIDS WITHOUT BChV INOCULATION, SALINAS, CA, 2003

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: March 5, 2003
Harvested: September 25, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Downey Mildew 5/07	Powdery Mildew 9/29	Virus Yellows Scores 7/02	7/21	8/15	9/02	Mean
Checks													
Y291H5	C833-5HO x RZM Y191	14646	46.40	15.75	136	83.7	1.5	4.1	1.4	2.1	1.8	2.0	1.8
Beta 6600	rec'd 7-11-00	14650	41.17	17.79	153	86.8	0.8	4.4	1.0	2.6	3.3	3.6	2.6
California commercial hybrids													
Phoenix	9-16-02, Holly Hybrids	11501	43.60	13.16	153	82.9	0.6	5.6	1.9	3.3	2.9	2.5	2.6
Beta 4430R	9-2002, Betaseed	10959	41.20	13.30	156	84.5	2.0	2.5	2.6	4.5	4.6	4.0	3.9
Eagle	9-16-02, Holly Hybrids	11667	41.87	13.90	152	84.0	1.9	5.4	3.1	3.4	3.4	3.4	3.3
Beta 4776R	9-2002, Betaseed	11593	39.81	14.56	163	85.4	2.0	1.9	2.8	4.1	4.3	3.5	3.7
Beta 4001R	9-2002, Betaseed	15239	49.28	15.49	166	86.7	1.9	1.9	1.6	2.8	2.6	3.0	2.5
US H11	1999 production, 10-4-02	10844	43.13	12.57	162	80.0	2.3	6.6	1.3	2.3	2.4	2.4	2.1
Colorado commercial hybrids													
Monohikari	1-21-03(8187),Seedex	11675	37.17	15.66	147	86.3	1.5	4.8	2.9	2.0	1.9	2.0	2.2
Beta 6045	2-22-02(011Z18FH2)	12796	38.92	16.43	148	84.3	1.3	4.4	1.8	2.9	2.9	2.5	2.5
HM9155	2-22-02(383-936)	13132	43.79	14.99	155	84.0	1.5	4.9	1.8	3.0	2.6	2.4	2.4
HM1639	2-22-02(515-047)	10917	40.10	13.64	159	82.3	2.5	4.8	3.1	2.8	2.6	2.8	2.8
Ranger	2-22-02(lot 8044),Seedex	11833	39.86	14.81	141	84.9	1.5	5.1	2.4	3.3	2.6	2.6	2.7
Crystal 205	2-22-02 (0205C8602)	11459	38.09	15.02	152	81.9	1.6	4.1	2.6	3.3	3.5	3.6	3.3
Beta 4546	2-22-02 (011130FH2)	14054	44.95	15.61	159	83.4	0.6	5.6	1.5	1.9	2.0	2.1	1.9
USDA Experimental hybrids													
2930-19H5	C833-5HO x RZM C930-19	12934	44.60	14.50	137	81.2	1.1	3.9	1.6	1.9	1.6	1.5	1.7
2930-35H5	C833-5HO x RZM C930-35	13498	40.16	16.75	134	83.1	1.3	4.4	1.5	2.4	2.0	2.5	2.1
Z210H5	C833-5HO x Z010(C)	13815	40.06	17.24	144	84.6	1.6	4.6	1.5	2.5	2.0	2.4	2.1
R278H50	C790-15CMS x RZM R178,C78/3	13580	44.92	15.09	147	83.6	1.8	4.6	1.5	2.0	1.6	1.5	1.7
R278H5	C833-5HO x RZM R178,C78/3	14648	45.20	16.17	123	85.0	1.3	5.0	1.6	1.9	1.8	1.8	1.8

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TEST 2603. PERFORMANCE OF COMMERCIAL HYBRIDS WITHOUT BChV INOCULATION, SALINAS, CA, 2003

(cont.)

| Variety | Description | Acre Yield | | | Beets/100' | RJAP | Downey Mildew | Powdery Mildew | Virus Yellows Scores | | | | |
		Sugar Lbs	Beets Tons	Sucrose %	No.	%	5/07	9/29	7/02	7/21	8/15	9/02	Mean
USDA Experimental hybrids (cont.)													
R278H2	C831-3HO x RZM R178,C78/3	12893	43.73	14.76	133	83.6	1.4	5.0	1.3	2.0	2.0	1.9	1.8
R278H27	C831-4HO x RZM R178	12000	43.33	13.82	139	81.0	2.4	4.6	1.6	2.0	2.3	2.0	2.0
R278H82	C833-5H2 x RZM R178	13425	43.33	15.49	128	85.4	0.5	4.8	1.5	1.9	1.8	1.9	1.8
R278H83	C833-5H27 x RZM R178	13617	45.55	14.95	139	83.2	1.5	4.6	1.8	2.0	1.8	1.8	1.8
Mean		12807.4	42.51	15.06	146.8	83.8	1.5	4.5	1.9	2.6	2.5	2.5	2.4
LSD (.05)		1251.2	2.92	0.97	10.3	3.2	1.2	0.6	0.7	0.5	0.6	0.6	0.4
C.V. (%)		9.9	6.97	6.50	7.1	3.9	82.9	13.7	39.2	21.0	24.0	24.8	15.3
F value		8.8**	7.77**	13.83**	9.9**	2.3**	1.5NS	25.3**	5.7**	14.4**	15.0**	10.8**	25.6**

NOTES: See test 2203 for BChV inoculated companion test. Varieties from Colorado were chosen with the help of Steve Godby, Western Sugar Company. They represent hybrids grown commercially in that area and particularly in the 1990s when BChV was severe.

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TEST 2703. PERFORMANCE OF EXPERIMENTAL HYBRIDS WITHOUT BChV INOCULATION, SALINAS, CA, 2003

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: March 5, 2003
Harvested: September 25, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Acre Yield Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/07	Powdery Mildew 9/29	Virus Yellows Scores 7/02	7/21	8/15	9/02	Mean
Commercial checks													
Beta 4776R	9-2002, Betaseed	12541	42.12	14.89	158	86.3	1.0	2.3	2.5	4.1	4.6	3.9	3.8
Eagle	9-16-02, Holly Hybrids	13047	44.44	14.68	151	85.4	1.5	5.0	2.1	3.6	4.3	3.8	3.4
Phoenix	9-16-02, Holly Hybrids	13174	46.42	14.19	148	85.2	1.4	5.4	1.8	3.0	4.0	3.0	2.9
Beta 4430R	9-2002, Betaseed	10891	40.81	13.30	156	84.5	1.8	3.1	3.3	4.6	5.1	4.3	4.3
Susceptible check													
Z210H50	C790-15CMS x Z010(C)	14132	43.34	16.35	144	84.0	1.4	4.9	1.4	2.3	2.1	2.4	2.0
Resistant population hybrids													
AY291H50	C790-15CMS x RZM Y191	14663	46.65	15.72	145	85.5	0.9	4.9	1.0	2.0	1.6	2.1	1.7
R278H50	C790-15CMS x RZM R178,C78/3	14065	45.37	15.48	147	85.0	1.8	4.8	1.4	2.0	1.6	1.6	1.7
R276-89H50	C790-15CMS x RZM-%R076-89	14040	44.99	15.60	154	84.3	2.1	4.4	0.8	1.5	1.4	1.6	1.3
Hybrids with FS pollinators													
R278-4H50	C790-15CMS x R078-4	13118	46.05	14.24	147	82.9	2.4	4.5	1.5	2.3	1.9	1.5	1.8
R280/2-9H50	C790-15CMS x R080/2-9	16001	50.19	15.95	147	85.7	0.4	5.4	0.4	1.9	2.3	1.8	1.6
R278-2H50	C790-15CMS x R078-2	13615	42.92	15.86	146	84.2	1.1	4.9	1.9	2.4	1.9	2.1	2.1
R278-7H50	C790-15CMS x R078-7	14091	45.90	15.34	146	83.7	2.6	5.0	1.8	2.3	2.1	1.4	1.9
R280-6H50	C790-15CMS x R080-6	16840	51.64	16.29	143	85.8	1.9	5.0	1.0	1.5	1.6	1.4	1.4
Y269-8H50	C790-15CMS x Y069-8	14472	45.27	15.96	139	85.1	0.6	4.9	1.5	2.4	1.9	1.8	1.9
Y269-18H50	C790-15CMS x Y069-18	14343	45.80	15.65	150	85.8	1.1	4.4	1.8	2.6	2.4	2.1	2.2
P207/8H50(Sp)	C790-15CMS x P007/8,CP07	12615	42.15	14.95	149	83.2	1.8	4.3	1.6	2.0	2.0	1.9	1.9
Hybrids with S1 pollinators													
1924-2H50	C790-15CMS x RZM 9924-2	14957	47.30	15.79	144	85.3	1.4	3.8	1.3	1.8	1.6	1.3	1.5
1927-4H50	C790-15CMS x RZM C927-4	15513	51.84	14.95	140	83.8	0.9	5.8	1.4	1.9	1.9	1.6	1.7
2930-19H50	C790-15CMS x RZM C930-19	14219	47.57	14.94	151	85.7	0.9	4.5	1.4	1.9	1.8	1.4	1.6
2930-35H50	C790-15CMS x RZM C930-35	14316	45.07	15.86	148	85.7	1.5	4.5	1.5	2.1	2.3	2.3	2.0

TEST 2703. PERFORMANCE OF EXPERIMENTAL HYBRIDS WITHOUT BChV INOCULATION, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield			Beets/100'		Downey Mildew	Powdery Mildew	Virus Yellows Scores				
		Sugar lbs	Beets Tons	Sucrose %	No.	RJAP %	5/07	9/29	7/02	7/21	8/15	9/02	Mean
Hybrids with S₁ pollinators (cont.)													
1929-4H50	C790-15CMS x RZM 9929-4	14617	46.01	15.89	145	85.9	1.6	4.0	1.3	1.9	1.6	1.8	1.6
2929-45H50	C790-15CMS x RZM 9929-45	14043	45.84	15.31	151	84.2	1.5	4.3	1.3	1.9	1.9	1.8	1.7
2936-10H50	C790-15CMS x RZM 0936-10	13643	43.84	15.55	144	84.8	1.9	4.9	1.5	1.5	1.8	1.1	1.5
2936-16H50	C790-15CMS x RZM 0936-16	14599	45.10	16.17	152	83.9	2.6	4.4	1.3	2.0	2.1	1.9	1.8
Mean		14064.9	45.69	15.37	147.7	84.8	1.5	4.5	1.5	2.3	2.3	2.1	2.1
LSD (.05)		1079.8	2.73	0.68	10.2	2.1	1.4	0.6	0.7	0.6	0.6	0.6	0.4
C.V. (%)		7.8	6.06	4.50	7.0	2.5	93.8	13.7	43.6	26.2	25.4	27.9	17.6
F value		9.6**	7.70**	9.14**	1.5NS	1.6NS	1.4NS	11.3**	6.0**	14.0**	24.9**	17.1**	37.2**

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NOTES: See test 2303. Experimental hybrids were chosen for tests 2303 and 2703 that had a history of being selected for virus yellows (BYV & BWYV) resistance. The S₁ and FS pollinators were partially selected because of their performance under virus yellows inoculated conditions at Salinas and Davis, CA, as well as for resistance to rhizomania and bolting.

Z010(C) = a composite of 2n = 2x high sugar accessions in about 1988 from Poland.

TEST 2903. EVALUATION OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS, SALINAS, CA, 2003

48 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: March 5, 2003
Harvested: September 24, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/08	Powdery Mildew 9/22
Checks								
Eagle	9-16-02, Holly Hybrids	12998	43.28	15.00	151	85.8	1.6	4.5
Beta 4430R	9-2002, Betaseed	11395	43.43	13.13	160	83.2	2.0	2.4
Phoenix	9-16-02, Holly Hybrids	12025	45.30	13.29	154	83.4	1.5	4.6
Beta 4776R	9-2002, Betaseed	12609	43.66	14.43	158	83.8	1.1	1.6
Retests & new seed productions								
Z025-9H50	C790-15CMS x Z825-9,CZ25-9	12839	41.37	15.50	160	82.3	1.4	2.1
0930-19H50	x 8930-19,C930-19	14003	47.54	14.71	156	84.3	2.3	2.6
2930-19H50	x RZM 1930-19, "	14641	49.13	14.91	151	84.7	1.1	2.9
1927-4H50	x RZM 9927-4,C927-4	15621	52.81	14.79	144	84.6	2.6	4.8
Z131-18H50[1]	x Z931-18	15997	51.17	15.63	127	84.7	0.5	2.4
2930-35H50	x RZM 1930-35,C930-35	14322	45.80	15.63	151	83.4	2.0	4.0
1929-4H50	x RZM 9929-4	15801	49.53	15.95	146	84.6	0.9	3.3
1936-14H50	x 9936-14	15078	49.96	15.09	143	84.4	0.5	2.6
2936-10H50	x RZM 0936-10	14338	46.93	15.27	147	84.8	2.4	3.9
2936-16H50	x RZM 0936-16	14560	44.79	16.26	151	84.2	2.0	3.1
2929-45H50	x 9929-45	14230	46.91	15.13	151	85.5	2.6	2.6
1931-56H50	x 9931-56	15089	50.59	14.91	139	83.7	0.9	1.8
1931-201H50	x 9931-201	14253	47.36	15.05	148	84.1	3.6	2.5
2942H50	x RZM-% 0942	14171	46.31	15.29	145	83.6	2.9	2.6
2943H50	x %S(C)	14706	45.71	16.09	141	85.0	1.8	3.1
2933H50	x RZM-% 9933	15785	49.73	15.86	150	86.2	2.6	3.6
1931H50(Sp)	x 9931(C)	13942	46.81	14.89	142	83.5	0.9	3.6
1941H50	x 0941	14876	48.25	15.46	129	84.7	2.0	3.1
Z131-18H50[1]	C790-15CMS x Z931-18	15551	49.75	15.63	134	84.3	0.9	2.3
Angelina	3-19-02, KWS	15225	48.47	15.73	155	84.3	2.5	7.5

TEST 2903. EVALUATION OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Downey Mildew 5/08	Powdery Mildew 9/22
Selected S_1 lines								
2931-3H50	C790-15CMS x 0931-3	14760	47.48	15.55	140	83.6	1.4	2.0
2941-20H50	x 0941-20	15168	48.36	15.66	145	84.9	0.5	3.6
2933-14H50	x 0933-14	15429	48.72	15.82	145	84.1	1.5	3.0
2933-17H50	x 0933-17	15366	50.39	15.24	135	84.9	1.4	3.8
2933-7H50	x 0933-7	15598	50.89	15.29	139	84.6	1.8	4.1
2931-20H50	x 0931-20	13955	47.01	14.79	128	83.9	1.5	2.9
CR211-7H50	x CR911-7(Sp)	14372	47.01	15.27	119	82.9	0.9	3.4
CR210-2H50	C790-15CMS x CR910-2(Sp)	12995	45.80	14.18	129	82.7	2.8	4.3
Hybrids with C833-5CMS								
Z225-9H5	C833-5CMS x RZM Z025-9,CZ25-9	13046	40.30	16.23	133	82.7	1.5	2.6
2927-4H5	x RZM 1927-4,C927-4	15724	51.44	15.25	98	83.4	1.0	4.6
2936-10H5	x RZM 0936-10	13817	44.39	15.56	142	85.1	1.5	3.8
2936-16H5	x RZM 0936-16	14197	42.62	16.65	139	81.5	2.4	3.0
2930-35H5	x RZM 1930-35,C930-35	14232	42.48	16.75	144	84.2	2.0	4.5
2930-19H5	x RZM 1930-19,C930-19	13857	45.48	15.23	133	84.9	1.6	3.3
2929-45H5	x 9929-45	13839	44.22	15.64	133	84.6	0.6	3.0
1931H5	X 9931(C)	13796	45.18	15.26	117	81.6	0.8	3.4
1929-4H5	x RZM 9929-4	15959	47.93	16.65	132	83.2	0.6	2.6
1941H5	x 0941	14074	45.74	15.36	126	83.2	1.5	3.6
2943H5	x %s(C)	14502	44.37	16.36	134	84.7	0.9	3.4
Z210H5	x Z#(C)	13907	39.38	17.67	135	84.8	1.3	4.1
P207/8H5	x P007/8,CP07	13281	43.28	15.29	134	82.0	2.0	3.1
Y277H5	x RZM R136-Y175(C)	12935	41.58	15.55	133	83.8	1.1	4.0
R278H5	C833-5CMS x RZM R178,C78/3	13794	44.03	15.66	122	83.4	1.6	4.3
N224H98	N165-9H50(g) x RZM-NR N124	11420	42.93	13.34	148	82.2	3.3	3.1

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TEST 2903.   EVALUATION OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield		Sucrose	Beets/ 100'	RJAP	Downey Mildew	Powdery Mildew
		Sugar Lbs	Beets Tons	%	No.	%	5/08	9/22
Mean		14251.5	46.37	15.37	139.9	84.0	1.6	3.4
LSD (.05)		1221.1	3.21	0.67	10.7	2.3	1.5	0.8
C.V. (%)		8.7	7.04	4.43	7.7	2.7	91.2	23.4
F value		6.6**	7.33**	12.14**	10.4**	1.6*	2.1**	12.9**

[1]Inadvertantly, Z131-18H50 was entered twice in this test.

NOTES: This series of tests from 2903-3803 was grown in an area following strawberry production in 2002 for which the soil had been fumigated with methylbromide/chloropricin.   Few weed problems occurred and there was no observed evidence of RHIZOMANIA, SUGARBEET CYST NEMATODE, or other soilborne problems.

Problems did occur for foliar diseases, however.   RUST developed early and remained severe on susceptible entries until mid-summer.   Although not scored, large differences were observed in host-plant reaction to wet and it appeared to have much the same influence as moderate to severe Cercospora would have on leaf health and duration.   Rust remained a chronic problem until drier summer conditions and an application of fungicide inhibited its re-infection.

DOWNEY MILDEW also developed early and persisted throughout the season although being somewhat ameliorated in mid-summer to fall by drier conditions.   Differential host-plant reactions were observed.   An attempt to score downy mildew by counting every plant that showed symptoms on 5/8/03 missed most of the infection and greatly underestimated its incidence and damaging effects.

POWDERY MILDEW developed in mid-summer and was controlled until near harvest by fungicide.   Powdery mildew was scored at harvest as it redeveloped on a scale of 0 to 9 where 9 is most severe.   Differences in entries were noted but likely PM did not greatly influence yield differentially.

VIRUS YELLOW developed after mid-June and was likely due to either or both Beet western yellows virus and Beet chlorosis virus (see tests 2103-2803).   Differential foliar yellowing occurred and probably virus yellows differentially affected yield (see tests 2103-2803).

TEST 2903. EVALUATION OF HYBRIDS WITH S₁ PROGENY LINE POLLINATORS, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Sucrose	RJAP	Downey Mildew	Powdery Mildew
		Sugar	Beets	No.			5/08	9/22
		Lbs	Tons	No.	%	%		

NOTES: (cont.)

Thus, unlike 2002 when similar tests were grown following strawberries and little disease or pest pressure occurred, these 2003 tests had significant disease pressure and affects that most likely differentially influenced yield. The most tolerant entries in these tests appeared to be from germplasm developed at Salinas that had previously been selected under the influence of virus yellows, rust, downy mildew, powdery mildew, etc.

See test 8103 for performance under rhizomania at Salinas and B303 & B403 for performance in Imperial Valley in 2003.

DESCRIPTIONS OF GERMPLASM: Most of the USDA entries were from experimental hybrids produced from progeny lines that had previously been evaluated and selected at Salinas. S₁ lines were from genetic-male-sterile facilitated, self-fertile (Sᶠ), random-mated populations. Full-sib lines were from improved self-sterile open-pollinated lines and populations. Most of these progeny lines had been evaluated for bolting tendency and performance in diseased and nondiseased trials at Salinas, Brawley, and Davis. Some of the progeny lines in addition had undergone one or more cycles of reselection. Two monogerm, CMS testers were used: C790-15CMS = rzrz F₁ hybrid (C790-68CMS x C790-15) that had been developed using S₁ progeny recurrent selection at Salinas. C833-5CMS = Rz inbred developed at Salinas for higher %S and resistance to rhizomania. Pollinators in addition to increases of S₁ and FS progeny included: 9931 & 9941 populations developed for combined disease resistance; 9933 has Colorado germplasm for resistance to root aphids, Rhizoctonia, and Cercospora; P007/8 and R136-Y175 have wild beet germplasm; N124 has SBCN resistance from B. procumbens; %S(C) is a composite of previously selected progeny lines with good % sugar; Z#(C) is a composite of 2n high %S accessions from Poland.

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TEST 3003. EVALUATION OF HYBRIDS WITH SELF-STERILE (S"S") POLLINATORS, SALINAS, CA, 2003

48 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: March 5, 2003
Harvested: September 24, 2003

Variety	Description		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Downey Mildew 5/08	Powdery Mildew 9/22
Checks									
Beta 4776R	9-2002	Betaseed	12365	43.08	14.35	158	83.8	0.8	1.3
Phoenix	9-16-02	Holly Hybrids	12614	46.36	13.61	148	84.3	0.9	4.5
Beta 4430R	9-2002	Betaseed	11743	43.69	13.41	154	83.3	0.9	1.8
Eagle	9-16-02	Holly Hybrids	13502	46.61	14.46	152	84.2	0.6	3.9
Hybrids with FS lines									
R278H50	C790-15CMS	x RZM-ER-%R178,C78/3	14851	47.67	15.61	140	84.9	0.5	3.6
R278-2H50		x R078-2	14403	46.12	15.61	139	84.5	1.0	3.1
R278-7H50		x R078-7	13842	45.06	15.36	146	84.3	1.1	3.9
R278-14H50		x R078-14	13922	45.93	15.14	139	83.6	0.4	2.5
R278-16H50		x R078-16	14849	47.98	15.46	134	82.9	1.0	2.6
R278-27H50		x R078-27	14015	45.35	15.45	139	83.4	0.6	3.0
R278-4H50		x R078-4	13272	46.15	14.36	143	83.5	1.5	3.1
R280/2-9H50		x R080/2-9	15955	50.63	15.75	138	84.6	0.1	4.6
R280-6H50		x R080-6	17308	54.12	16.00	145	86.0	0.1	3.5
Y269-8H50		x Y069-8	14986	46.71	16.05	144	84.0	0.3	3.1
Y269-18H50		x Y069-18	13233	43.09	15.35	144	84.3	0.9	3.3
Y269-39H50		x Y069-39	15485	49.88	15.54	151	83.5	1.3	2.0
Y291H50		x RZM Y191	15264	49.23	15.49	143	83.3	0.8	3.4
R276-89H50		x RZM-% R076-89	14380	46.43	15.51	144	85.0	1.3	3.3
Y290H50		x RZM-% Y090	15891	49.83	15.94	142	84.3	0.4	3.3
Z210H50		x %S(C)	15323	45.06	17.01	144	84.9	1.3	4.0
P207/8H50		x RZM-PMR-NR P007/8	14241	46.61	15.27	144	85.2	1.4	2.1
P207/8H50		x P007/8	13766	46.67	14.74	139	84.2	1.1	2.6
P229-8H50		x P029-8	13933	44.99	15.48	134	83.6	0.8	3.3
P229-20H50	C790-15CMS	x P029-20	15308	49.33	15.52	150	84.0	1.9	3.9

(cont.)

Variety	Description		Acre Yield Sugar Lbs	Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/08	Powdery Mildew 9/22
Hybrids with FS lines (cont.)									
P230-10H50	C790-15CMS	x P030-10	14830	46.36	15.99	151	84.1	2.4	3.2
P230-17H50		x P030-17	14367	48.57	14.76	143	83.3	0.8	3.8
Y275H50		x RZM-% Y075	14470	48.42	14.96	141	83.8	0.8	3.3
Y275-16H50		x Y075-16	14361	46.26	15.48	146	82.7	0.9	4.8
Y267-21H50		x Y067-21	15551	48.33	16.11	130	85.3	0.8	2.9
Y267-24H50		x Y067-24	14492	50.50	14.31	147	84.4	0.5	3.3
Y267-34H50		x Y067-34	15267	49.53	15.45	142	84.7	0.8	3.1
Y271-14H50		x Y071-14	14461	48.65	14.88	146	82.6	2.1	3.8
Y277H50		x RZM R136-Y175	14468	47.31	15.31	139	83.8	1.0	3.5
R243-14H50	C790-15CMS	x R043-14	14257	47.29	15.05	139	84.5	1.6	2.8
Angelina	3-19-02	KWS	15860	49.21	16.11	150	86.9	0.8	7.1
R270-18H50	C790-15CMS	x R070-18	14263	46.86	15.21	129	82.2	1.0	3.9
Retests									
R178-6H50	C790-15CMS	x R978-6	14885	51.69	14.43	134	83.0	0.8	3.4
R180-21H50		x R980-21	15959	49.88	16.02	144	86.0	0.6	4.1
R181-22H50		x R981-22,C81-22	15572	48.61	15.98	138	86.4	1.4	2.8
2930-19H50		x RZM 1930-19,C930-19							
			14527	48.93	14.85	146	83.9	1.1	3.0
Hybrids with C833-5CMS									
R278H5	C833-5CMS	x RZM R178, C78/3	14242	44.80	15.89	119	83.1	0.6	4.4
R278-4H5		x R078-4	13412	44.28	15.20	134	83.9	1.3	3.5
R280/2-9H5		x R080/2-9	15598	47.51	16.42	133	82.5	0.8	4.6
Y291H5		x RZM Y191	15098	47.86	15.74	131	82.5	0.6	4.0
Z210H5		x %s(C)	14560	42.53	17.10	137	82.6	0.9	3.1
P207/8H5		x P007/8, CP07	13120	42.79	15.31	133	82.2	1.1	3.0
Y277H5		x RZM R136-Y175	12914	41.71	15.46	127	82.9	0.8	4.0
2930-19H5	C833-5CMS	x RZM 1930-19,C930-19							
			13523	44.33	15.21	128	82.1	0.8	3.1

TEST 3003. EVALUATION OF HYBRIDS WITH SELF-STERILE (S^sS^s) POLLINATORS, SALINAS, CA, 2003

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/ 100' | RJAP | Downey Mildew 5/08 | Powdery Mildew 9/22 |
		Sugar Lbs	Beets Tons	%	No.	%		
Mean		14468.9	47.06	15.37	140.9	83.9	0.9	3.4
LSD (.05)		1179.1	2.90	0.78	10.0	2.2	1.0	0.8
C.V. (%)		8.3	6.27	5.15	7.2	2.7	113.0	23.8
F value		6.2**	6.03**	6.68**	4.7	1.9**	1.5*	10.1**

NOTES: See notes for test 2903. Test 3003 is composed mostly of experimental hybrids with pollinators derived from full-sib progeny evaluation and selection.

DESCRIPTIONS: R078-#s are from C78/3; R080/2 & R080-#s are from C80/2; Y069-#s are from C69/2; P#s have powdery mildew resistance from WB97 or 242. P207/8 = CP07; Y075-#s, Y067-#s, Y071-#s, R043-14 have rhizomania resistance from Rz1 and C50 or C51 (R22) germplasm; R981-22 was released as C81-22 in 2003; line Y191 = Syn 2, Cycle 1 by FS selection; Y090 = Syn 1, cycle 2 by FS selection; %S(C) = composite of 2n = 2x high % sugar accessions from Poland; Y075 & R136-Y175 have germplasm from WB thru C51 (R22).

See test 8203 for performance under rhizomania at Salinas and B203 & B503 for performance in Imperial Valley in 2003.

A78

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: March 5, 2003
Harvested: September 22, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/08	Powdery Mildew 9/19
Check								
Beta 4430R	9-2002	13183	46.37	14.14	155	84.2	1.1	2.0
Phoenix	9-16-02	13016	47.01	13.77	152	85.1	1.0	4.0
Topcrosses to Y91								
Y291H50	C790-15CMS x RZM Y191	14936	48.12	15.45	140	82.6	0.8	3.0
Y291H5	C833-5HO x RZM Y191	14773	45.96	16.05	138	84.3	0.8	2.9
Y291H73	01-FC123H5 x RZM Y191	13669	45.10	15.15	129	84.2	0.3	3.4
Y291H74	01-FC1014H5 x RZM Y191	14574	46.66	15.61	137	83.1	0.9	3.0
Topcrosses to R78 (C78/3)								
R278H73	01-FC123H5 x RZM R178	14432	45.36	15.91	135	83.2	0.9	3.1
R278H74	01-FC1014H5 x RZM R178	14484	45.70	15.82	140	82.7	1.3	3.1
R278H50	C790-15CMS x RZM R178	14363	47.16	15.21	140	84.3	1.1	3.3
R278H5	C833-5HO x RZM R178	13600	43.70	15.55	116	82.7	0.9	3.5
R278H6	C833-5H50 x RZM R178	14530	46.96	15.49	133	83.1	0.9	3.5
R278H95	N165-#(g)mmaa x RZM R178	10237	38.82	13.13	108	81.0	1.0	3.3
R278H75	1835-11H5 x RZM R178	13457	46.00	14.59	129	79.8	1.3	3.5
R278H76	1835-26H5 x RZM R178	13278	44.17	15.02	106	82.0	0.9	3.1
R278H2	C831-3HO x RZM R178	12925	44.01	14.66	115	82.3	1.1	3.1
R278H27	C831-4HO x RZM R178	12875	46.28	13.88	123	80.8	2.1	3.3
R278H77	1833-5-8HO x RZM R178	14185	44.09	16.10	128	83.5	0.6	3.3
R278H78	1833-5-11HO x RZM R178	14637	45.40	16.10	114	84.0	0.9	3.4
R278H45	C867-1HO x RZM R178	12453	46.46	13.43	137	80.7	1.4	2.8
R278H46	9869-6HO x RZM R178	13286	45.55	14.59	136	82.9	2.3	4.6

TEST 3103. EVALUATION OF TOPCROSS HYBRIDS, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield		Sucrose	Beets/ 100'	RJAP	Downey Mildew	Powdery Mildew
		Sugar Lbs	Beets Tons	%	No.	%	5/08	9/19
Topcrosses to R78 (cont.)								
R278H67	0837-6H5 x RZM R178	13477	44.29	15.23	129	83.2	0.6	3.6
Y291H23	CZ25-9aa x RZM Y191	12527	39.91	15.70	136	83.4	0.8	2.3
R278H23	CZ25-9aa x RZM R178	12413	40.59	15.26	133	83.8	0.9	2.0
R278H40	C930-35aa x RZM R178	11939	38.64	15.43	116	82.5	0.9	2.5
Mean		13468.7	44.68	15.05	130.2	82.9	1.0	3.6
LSD (.05)		1252.5	2.91	0.84	12.1	3.0	1.1	0.7
C.V. (%)		9.4	6.60	5.68	9.4	3.7	107.4	108.5
F value		6.0**	6.40**	8.04**	8.7**	1.5NS	1.3NS	1.2NS

NOTES: See test 8303 under rhizomania. See test 2903 for cultural conditions.

DESCRIPTIONS: H5 = C833-5CMS used as CMS. HO = CMS. "C" prefix designates lines that have been released. FC123 released in 2003 as FC301 by Panella & Lewellen. FC1014 released as FC201.

TEST 3803. EVALUATION OF POPULATION HYBRIDS, SALINAS, CA, 2003

48 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: March 5, 2003
Harvested: October 7, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/08	Powdery Mildew Mean	Bolting %	Root Rot %
Checks										
Phoenix	9-16-02	13762	48.72	14.10	148	83.4	0.5	5.4	0.0	0.0
Beta 4776R	9-2002	13662	46.36	14.75	159	82.5	0.3	1.6	0.0	0.0
Beta 4430R	9-2002	12530	46.77	13.38	148	84.0	0.3	2.8	0.0	0.0
Eagle	9-16-02	12719	43.94	14.43	152	82.0	0.8	5.0	0.0	0.0
Lines and populations										
R278	RZM R178,C78/3	11348	37.98	14.90	102	82.4	0.5	4.0	0.0	2.5
R291	RZM Y191	13474	44.35	15.30	139	84.3	0.0	3.9	0.0	1.7
2931	RZM-% 0931 (A,aa)	14467	46.16	15.85	143	87.5	0.0	2.8	0.0	0.0
2941	RZM-% 0941 (A,aa)	15290	50.60	15.05	155	83.7	0.5	3.3	0.0	0.0
Z225	RZM-% Z025 (A,aa)	12985	42.73	15.10	150	80.9	0.5	4.6	0.0	0.0
2930-35	RZM 1930-35aa x A,C790-35	11687	34.47	16.98	139	84.2	0.5	3.8	4.7	0.0
Z025-9	Z825-9aa x A,CZ25-9	10552	32.68	16.02	134	80.7	0.0	2.1	0.0	0.0
CR211	RZM-% CR011 (A,aa)	13457	47.73	14.07	127	81.4	0.3	4.4	0.0	0.0
Population hybrids										
R278H31	RZM 1931(Iso)aa x RZM R178	14207	47.77	14.80	139	82.4	0.3	3.3	0.0	0.0
R278H41	RZM 1941aa x RZM R178	13177	43.52	15.02	118	83.6	0.5	3.0	0.0	0.0
R278H25	Z125aa x RZM R178	13108	43.14	15.18	118	82.6	0.8	3.5	0.0	0.0
R278H40	1930-35aa x RZM R178	13672	44.55	15.32	120	82.0	0.5	3.5	0.0	0.0
R278H23	Z025-9aa x RZM R178	12071	38.50	15.57	132	82.9	0.3	3.0	0.0	0.0
Y291H31	RZM 1931aa x RZM Y191	12767	43.74	14.63	132	83.3	0.3	4.1	0.0	0.0
Y291H41	RZM 1941aa x RZM Y191	15096	48.98	15.35	130	83.9	0.8	4.0	0.0	3.1
Y291H11	RZM CR111aa x RZM Y191	10440	35.78	14.30	139	80.8	0.0	3.9	0.0	0.0
Y291H25	RZM Z125aa x RZM Y191	14080	46.77	15.07	136	84.9	0.0	3.6	0.0	0.0
Y291H23	Z025-9aa x RZM Y191	12680	40.01	15.88	143	83.6	0.5	3.4	0.0	0.0

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TEST 3803. EVALUATION OF POPULATION HYBRIDS, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Downey Mildew 5/08	Powdery Mildew Mean	Bolting %	Root Rot %
Population hybrids(cont.)										
Y291H5	C833-5HO x RZM Y191	15968	49.79	16.05	141	83.0	0.5	4.1	0.0	0.0
Y291H50	C790-15CMS x RZM Y191	15943	50.60	15.75	145	84.9	1.3	4.1	0.0	0.0
R278H5	C833-5HO x RZM R178	14722	45.15	16.33	118	83.3	1.0	4.5	0.0	0.0
R278H50	C790-15CMS x RZM R178	14541	48.18	15.13	139	82.4	1.3	4.0	0.0	0.0
R278H96	N165HO (w/o g) x RZM R178	13867	49.99	13.85	125	82.9	0.8	3.8	0.0	0.0
R278H97	N167HO (w/o g) x RZM R178	14405	47.37	15.17	139	83.8	0.3	3.4	0.0	0.0
R278H56	1836HO x RZM R178	14652	48.58	15.10	132	84.1	0.8	4.6	0.0	0.0
R278H42	1842HO(A) x RZM R178	14544	48.98	14.88	150	84.2	0.5	4.1	0.0	0.0
R278H55	1835HO x RZM R178	14197	47.97	14.75	134	83.1	0.0	4.6	0.0	1.7
R278H70	1869HO x RZM R178	13997	47.57	14.65	132	82.0	0.3	4.6	0.0	0.0
Checks										
Beta 4001R	9-2002	15418	48.78	15.82	157	84.9	1.8	1.9	0.0	0.0
Angelina	3-19-02	16632	50.70	16.38	141	86.2	1.0	6.8	0.0	0.0
Z210 polycross										
Z210H5	C833-5HO x Z10(C)	16219	46.77	17.40	130	84.2	1.0	4.4	0.0	0.0
Z210H50	C790-15CMS x Z10(C)	16243	49.39	16.45	143	84.6	0.5	4.3	0.0	0.0
Z210	Inc. Z010(C)	11611	33.06	17.65	143	84.3	1.0	4.8	0.0	0.0
Z210-1	Z011 x Z010(C)	13025	34.87	18.70	143	85.0	0.5	4.8	0.0	0.0
Z210-2	Z012 x Z010(C)	11131	34.69	15.95	134	81.1	1.5	4.8	0.0	0.0
Z210-3	Z013 x Z010(C)	13847	39.71	17.42	136	85.5	1.0	3.4	0.0	1.6
Z210-4	Z014 x Z010(C)	12109	33.66	17.98	136	84.4	0.5	3.4	0.0	1.7
Z210-7	Z017 x Z010(C)	12315	35.48	17.35	132	83.4	1.8	4.0	0.0	3.3
943 %S line polycross										
2943-9	RZM Z025-9aa x 943C	12783	40.52	15.78	134	82.6	0.8	2.8	0.0	0.0
2943-35	1930-35aa x 943C	12211	40.92	14.85	145	81.7	0.3	3.5	3.1	0.0

TEST 3803. EVALUATION OF POPULATION HYBRIDS, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Downey Mildew 5/08	Powdery Mildew Mean	Bolting %	Root Rot %
Z210 polycross (cont.)										
2943-19	C930-19aa x 943(C)	14365	45.96	15.63	136	84.6	0.5	2.4	0.0	0.0
2943-14	RZM Z131-14aa x 943(C)	11745	41.12	14.27	130	82.9	0.8	2.6	0.0	0.0
2943-20	RZM Z131-20aa x 943(C)	12342	40.38	15.25	127	82.2	0.3	2.3	0.0	0.0
2943H5	C833-5HO x 943(C)	15724	47.97	16.48	125	81.5	0.3	4.1	0.0	0.0
Mean		13578.9	43.82	15.54	136.5	83.3	0.6	3.8	0.2	0.3
LSD (.05)		2878.8	8.77	1.22	16.8	3.7	1.2	0.9	1.7	2.2
C.V. (%)		15.2	14.32	5.61	8.8	3.2	153.1	17.2	765.9	493.7
F value		2.2**	3.00**	6.65**	3.4**	1.2NS	1.0NS	8.8**	1.7*	1.1NS

NOTES: See test 6303 for performance under rhizomania. See test 2903 for cultural conditions.

Tests 3803 & 6303 were grown to identify population hybrids from which S_1's could be generated that possess improved disease resistance, bolting, and agronomic performance.

R278 & R291 are O.P.,S^sS^s breeding lines. 2931, 2941, Z225 & CR211 are MM,S^f,A:aa popns. Individual plants from population hybrids between the O.P. lines and S^f popns could be selfed to produce S_1 progeny. Z025-9 (CZ25-9) and C930-35 are MM,S^f,A:aa lines. Z210-#s are polycrosses from individual Polish accessions. 2943-#s are polycrosses among lines CZ25-9, C930-35, Z131-14,Z131-18,Z131-20, and C930-19. All except C930-19 have some germplasm derived from Polish accessions.

TEST 2203. PERFORMANCE OF COMMERCIAL HYBRIDS UNDER BChV INOCULATION, SALINAS, CA, 2003

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: March 5, 2003
Harvested: October 1, 2003
Inoc. BChV: May 9, 2003

| Variety | Description | Acre Yield | | | Sucrose | Beets/100' | RJAP | Downey Mildew | Powdery Mildew | Virus Yellows Scores | | | | Mean |
		Sugar Lbs	Loss[1] %	Beets Tons	%	No.	%	5/07	9/29	7/02	7/21	8/15	9/02	
Checks														
Y291H5	C833-5HO x RZM Y191	12246	16.39	39.40	15.53	135	84.1	2.5	4.4	2.9	3.4	2.5	3.3	3.0
Beta 6600	rec'd 7-11-00	9885	32.53	29.85	16.58	149	87.0	0.4	4.5	4.0	5.3	5.0	4.8	4.8
California commercial hybrids														
Phoenix	9-16-02, Holly Hybrids	8551	25.65	31.91	13.43	158	85.2	2.9	5.5	4.4	4.9	3.9	3.9	4.3
Beta 4430R	9-2002, Betaseed	7990	27.09	31.29	12.74	160	84.0	3.0	3.1	5.3	6.1	5.0	4.8	5.3
Eagle	9-16-02, Holly Hybrids	8379	28.18	30.53	13.75	149	84.2	2.9	5.4	5.0	5.5	5.0	4.6	5.0
Beta 4776R	9-2002, Betaseed	9509	17.98	33.56	14.16	161	84.5	1.9	2.1	4.9	5.4	4.9	5.0	5.0
Beta 4001R	9-2002, Betaseed	11895	21.94	39.96	14.88	158	84.6	3.4	1.9	4.0	5.1	4.8	5.1	4.8
US H11	1999 production, 10-4-02	8999	17.01	35.37	12.68	156	82.3	5.6	6.3	3.1	3.5	2.8	2.9	3.1
Colorado commercial hybrids														
Monohikari	1-21-03 (8187), Seedex	8440	27.71	27.86	15.10	155	85.5	3.5	5.0	4.0	3.5	3.3	4.0	3.7
Beta 6045	2-22-02 (011Z18FH2)	9869	22.87	30.46	16.20	160	86.9	2.5	4.5	4.6	5.1	4.0	4.5	4.6
HM9155	2-22-02 (383-936)	10104	23.06	35.72	14.14	159	84.4	2.0	4.6	3.5	4.5	3.5	3.6	3.8
HM1639	2-22-02 (515-047)	6499	40.47	25.45	12.77	160	81.5	3.3	4.4	5.0	5.1	4.9	4.9	5.0
Ranger	2-22-02 (lot 8044),Seedex	9127	22.87	31.54	14.48	155	84.1	2.5	5.0	4.3	4.8	3.8	4.0	4.2
Crystal 205	2-22-02 (0205C8602)	7336	35.98	26.40	13.89	156	81.8	3.3	4.9	4.8	5.1	5.4	5.4	5.2
Beta 4546	2-22-02 (011130FH2)	11214	20.21	35.37	15.85	157	85.2	3.1	5.0	3.5	3.5	2.6	3.1	3.2
USDA Experimental hybrids														
2930-19H5	C833-5HO x RZM C930-19	11433	11.61	38.46	14.84	144	82.3	3.8	3.0	2.8	2.4	2.3	2.5	2.5
2930-35H5	C833-5HO x RZM C930-35	10892	19.31	33.71	16.16	148	82.7	3.3	4.5	3.1	3.8	3.9	4.5	3.8
Z210H5	C833-5HO x Z010(C)	9984	27.73	30.41	16.41	146	83.5	1.6	3.9	3.9	4.9	4.4	4.8	4.5
R278H50	C790-15CMS x RZM R178	11788	13.20	38.75	15.19	144	84.7	3.9	3.8	3.0	3.0	2.5	3.5	3.0
R278H5	C833-5HO x RZM R178, C78/3	11166	23.77	36.64	15.24	135	83.9	3.3	4.3	3.1	3.6	2.6	3.5	3.2

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(cont.)

Variety	Description	Acre Yield		Beets	Sucrose	Beets/100'	RJAP	Downey Mildew	Powdery Mildew	Virus Yellows Scores				
		Sugar Loss[1]		Beets										
		lbs	%	Tons	%	No.	%	5/07	9/29	7/02	7/21	8/15	9/02	Mean
USDA Experimental hybrids (cont.)														
R278H2	C831-3HO x RZM R178,C78/3	10133	21.41	36.28	13.95	133	82.3	3.4	4.4	3.5	3.6	2.5	3.0	3.2
R278H27	C831-4HO x RZM R178,C78/3	10581	11.83	39.35	13.41	139	81.3	5.0	4.1	3.3	2.6	2.5	3.0	2.8
R278H82	C833-5H2 x RZM R178,C78/3	10833	19.31	36.78	14.74	130	83.7	1.6	4.3	3.0	3.5	2.3	3.1	3.0
R278H83	C833-5H27 x RZM R178,C78/3	11440	15.99	38.57	14.85	140	83.7	3.4	3.9	3.4	3.4	2.8	3.3	3.2
Mean		9929.0		33.90	14.62	149.5	83.9	3.0	4.3	3.8	4.2	3.6	4.0	3.9
LSD (.05)		822.8		2.45	0.60	9.5	2.2	2.0	0.6	0.6	0.5	0.6	0.5	0.3
C.V. (%)		8.4		7.35	4.17	6.4	2.7	67.8	14.1	15.7	12.4	18.1	12.5	8.8
F value		26.5**		23.78**	29.20**	8.5**	3.8**	2.3**	22.0**	13.2**	30.6**	21.6**	23.3**	53.0

[1]Test 2203 and Test 2603 are companion tests. Test 2203 was inoculated May 9, 2003 with *Beet chlorosis virus* (BChV).
% loss is the relative sugar yield loss calculated from the corresponding means in each test.

Notes: Virus yellows foliar symptoms were scored on a scale of 0 to 9, where 9 = 90-100% of the mature leaf area yellowed. Scores were made on 7/2, 7/21, 8/15 and 9/2/03 by JAO.

Correlations within VY inoculated test 2203

	SY	RY	%S	RJAP	%loss
VY mean	-.66**	-.72**	-.15NS	.24NS	.75**
VY 9/02	-.51*	-.66**	.05NS	.22NS	.70***
VY 8/15	-.63**				.74***
VY 7/21	-.61**				.71***
VY 7/02	-.78**				.70***
% sugar	.58**				

Correlations between corresponding tests
Non-inoculated test (Test 2603)

	SY	%S	VY mean	VY 9/02	VY 8/15	VY 7/21	VY 7/0
VY Inoc.							
SY	.83**						
%S		.94**					
VY mean			.89**				
VY 9/02				.82**			
VY 8/15					.80**		
VY 7/21						.87**	
VY 7/02							.76**

TEST 2303. PERFORMANCE OF EXPERIMENTAL HYBRIDS UNDER BChV INOCUATION, SALINAS, CA, 2003

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: March 5, 2003
Harvested: September 30, 2003
Inoc. BChV: May 9, 2003

Variety	Description	Acre Yield Sugar lbs	Loss[1] %	Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/07	Powdery Mildew 9/29	Virus Yellows Scores 7/02	7/21	8/15	9/02	Mean
Commercial checks														
Beta 4776R	9-2002, Betaseed	9648	23.07	35.17	13.68	167	84.3	2.8	2.5	4.9	5.0	5.1	4.8	4.9
Eagle	9-16-02, Holly Hybrids	8711	33.23	31.39	13.84	148	84.0	1.6	5.6	4.9	5.0	5.3	4.6	4.9
Phoenix	9-16-02, Holly Hybrids	8927	32.24	32.63	13.68	155	85.0	2.1	6.0	4.8	4.9	4.5	4.0	4.5
Beta 4430R	9-2002, Betaseed	8420	22.69	32.00	13.13	158	83.8	3.1	3.6	5.0	5.5	5.3	5.0	5.2
Susceptible check														
Z210H50	C790-15CMS x Z010(C)	10859	23.16	34.67	15.67	146	83.8	1.1	4.8	3.9	4.0	3.6	4.4	4.0
Resistant population hybrids														
Y291H50	C790-15CMS x RZM Y191	13169	10.19	43.23	15.23	152	84.5	2.1	4.9	2.9	2.9	2.9	3.1	2.9
R278H50	C790-15CMS x RZM R178	12291	12.61	40.52	15.15	143	84.1	3.0	4.1	2.8	3.0	3.0	2.9	2.9
R276-89H50	C790-15CMS x RZM-% R076-89	12603	10.24	41.91	15.02	153	83.9	3.4	4.3	2.3	1.9	1.9	2.3	2.1
Hybrids with FS pollinators														
R278-4H50	C790-15CMS x R078-4	10949	16.53	39.55	13.84	155	84.4	6.6	4.4	3.6	3.3	2.9	3.1	3.2
R280/2-9H50	C790-15CMS x R080/2-9	13623	14.86	43.47	15.68	147	85.0	1.4	4.9	2.6	3.4	3.5	3.4	3.2
R278-2H50	C790-15CMS x R078-2	12241	10.10	39.07	15.68	157	84.9	3.6	4.1	3.4	3.5	3.1	3.5	3.4
R278-7H50	C790-15CMS x R078-7	11360	19.38	37.86	14.99	146	84.7	4.9	4.8	3.8	2.8	3.1	3.6	3.3
R280-6H50	C790-15CMS x R080-6	14451	14.19	46.26	15.63	151	86.0	1.6	4.5	2.9	2.9	2.4	2.4	2.6
Y269-8H50	C790-15CMS x Y069-8	13115	9.38	42.38	15.46	151	84.6	1.9	4.0	2.8	3.0	2.9	3.3	3.0
Y269-18H50	C790-15CMS x Y069-18	12234	14.70	39.53	15.46	148	85.9	1.1	4.0	3.4	3.5	3.5	4.3	3.7
P207/8H50(Sp)	C790-15CMS x P007/8	11234	10.95	37.62	14.93	149	84.0	4.0	3.8	3.0	3.0	3.0	3.1	3.0
Hybrids with S₁ pollinators														
1924-2H50	C790-15CMSxRZM 9924-2	13357	10.70	43.87	15.23	144	83.8	3.5	3.1	2.5	2.6	2.1	2.6	2.5
1927-4H50	C790-15CMSxRZM C927-4	13429	13.43	45.35	14.77	144	83.2	3.3	5.0	2.9	2.6	2.5	2.8	2.7
2930-19H50	C790-15CMSxRZM C930-19	11880	16.45	40.58	14.64	150	83.8	2.5	4.1	3.1	2.1	2.1	2.5	2.5
2930-35H50	C790-15CMSxRZM C930-35	11474	19.85	37.20	15.41	152	85.0	2.6	4.6	3.6	3.5	4.0	4.4	3.9

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TEST 2303. PERFORMANCE OF EXPERIMENTAL HYBRIDS UNDER BChV INOCUATION, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Loss[1] %	Beets Tons	Beets Sucrose %	Beets/100' No.	RJAP %	Downey Mildew 5/07	Powdery Mildew 9/29	Virus Yellows Scores 7/02	7/21	8/15	9/02	Mean
Hybrids with S₁ pollinators (cont.)														
1929-4H50	C790-15CMSxRZM 9929-4	12568	14.02	41.65	15.06	146	83.4	1.9	3.8	3.1	3.4	3.3	3.5	3.3
2929-45H50	C790-15CMSxRZM 9929-45	11931	15.04	40.21	14.84	155	83.7	3.1	3.5	2.9	2.5	2.6	3.1	2.8
2936-10H50	C790-15CMSxRZM 0936-10	12267	10.09	39.45	15.52	147	85.3	3.5	4.9	2.8	2.3	2.8	2.9	2.7
2936-16H50	C790-15CMSxRZM 0936-16	12911	11.56	40.76	15.82	147	84.6	3.9	3.9	3.1	3.0	3.3	3.1	3.1
Mean		11818.8		39.43	14.93	150.5	84.4	2.9	4.3	3.4	3.3	3.3	3.5	3.3
LSD (.05)		976.9		2.70	0.59	9.7	2.0	2.1	0.6	0.6	0.5	0.6	0.5	0.3
C.V. (%)		8.4		6.94	4.02	6.5	2.4	73.0	14.2	16.9	16.1	19.7	15.6	9.4
F value		20.7**		17.38**	12.80**	2.5**	1.1NS	3.0**	12.7**	1.3**	25.7**	17.6**	17.0**	57.2

[1] Test 2303 and Test 2703 are companion tests. Test 2303 was inoculated May 9, 2003 with *Beet chlorosis virus* (BChV).
% loss is the relative sugar yield loss calculated from the corresponding means in each test.

Notes: Virus yellows foliar symptoms were scored on a scale of 0 to 9, where 9 = 90-100% of the mature leaf area yellowed. Scores were made on 7/2, 7/21, 8/15 and 9/2/03 by JAO.

Correlations within VY inoculated test 2303

	SY	RY	%S	RJAP	%loss
VY mean	-.84**	-.85**	-.62**	.02NS	.81**
VY 9/02	-.76**	-.81**	-.45*	-.05NS	.71**
VY 8/15	-.80***				.78***
VY 7/21	-.78***				.78***
VY 7/02	-.90**				.87***
% sugar	.81**				

Correlations between corresponding tests

	Non-inoculated test (Test 2703)						
VY Inoc.	SY	%S	VY mean	VY 9/02	VY 8/15	VY 7/21	VY 7/0
SY	.86**						
%S		.93**					
VY mean			.92**				
VY 9/02				.85**			
VY 8/15					.92**		
VY 7/21						.90**	
VY 7/02							.81**

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TEST 8103. PERFORMANCE OF S_1 PROGENY LINE HYBRIDS UNDER RHIZOMANIA, SALINAS, CA, 2003

48 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: April 25, 2003
Harvested: October 14, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Missing Feet No.	Root Rot %	RJAP %	Powdery Mildew 10/20
Checks									
Eagle	9/16/02	6430	21.09	15.26	162	1.3	4.8	84.6	3.9
Beta 4430R	2/12/03	7489	24.82	15.20	219	0.4	2.5	86.4	2.0
Phoenix	9/16/02	6657	22.63	14.71	159	2.4	4.5	86.2	4.0
Beta 4776R	2/12/03	8109	26.55	15.35	216	0.3	3.2	85.4	1.3
Retests & new seed productions									
Z025-9H50	C790-15CMS x Z825-9	8122	24.84	16.36	207	0.5	5.4	83.8	2.5
1931-201H50	x 9931-201	8853	29.95	14.73	188	0.9	5.1	84.7	2.1
2930-19H50	x RZM 1930-19	7876	26.38	14.91	205	1.0	5.4	84.2	3.0
1927-4H50	x RZM 9927-4	8383	28.39	14.80	196	0.9	7.7	84.9	4.3
Z131-18H50	x Z931-18	7329	24.10	15.23	181	0.6	3.8	85.3	3.0
2930-35H50	x Z1930-35	8412	26.78	15.74	198	0.4	5.0	83.9	4.0
1929-4H50	x RZM 9927-4	7551	24.67	15.30	201	0.5	5.4	83.7	3.1
1936-14H50	x 9936-14	7830	25.99	15.05	193	0.5	2.3	84.3	3.3
2936-10H50	x RZM 0936-10	8214	25.88	15.94	195	1.8	5.7	84.9	3.5
2936-16H50	x RZM 0936-16	7301	23.16	15.75	210	0.8	4.8	84.2	3.1
2929-45H50	x 9929-45	7360	24.39	15.09	195	1.0	5.0	84.8	3.0
1931-56H50	x 9931-56	8855	29.11	15.23	160	1.0	6.1	85.3	1.9
Population hybrids									
Roberta	3/25/03	2381	9.22	12.95	216	4.4	2.7	82.3	1.8
2942H50	C790-15CMS x RZM-% 0942	6710	23.19	14.46	198	0.3	0.9	83.9	3.1
2943H50	x %S(C)	6740	22.14	15.29	202	0.4	2.7	84.2	3.1
2933H50	x RZM-% 9933	7038	24.18	14.55	216	0.3	1.8	83.9	3.5
1931H50(Sp)	x 9931(C)	7649	26.44	14.46	189	0.5	4.6	83.4	3.1
1941H50(Sp)	x 0941	7117	24.08	14.79	189	1.4	3.9	83.7	3.8
Beta 4001R	2/12/03	9099	28.87	15.79	222	0.0	2.5	84.8	1.1
Angelina	3/19/02	8862	28.69	15.46	206	0.8	5.0	84.4	6.4

TEST 8103. PERFORMANCE OF S₁ PROGENY LINE HYBRIDS UNDER RHIZOMANIA, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Missing Feet No.	Root Rot %	RJAP %	Powdery Mildew 10/20
Selected S₁ lines									
2931-3H50	C790-15CMS x 0931-3	8275	28.20	14.65	205	1.4	9.6	84.2	2.3
2941-20H50	x 0941-20	7785	25.99	15.00	206	0.4	5.7	84.3	3.4
2933-14H50	x 0933-14	7783	25.20	15.45	214	0.3	1.9	84.8	3.6
2933-17H50	x 0933-17	8487	28.05	15.10	152	1.3	5.1	84.0	3.8
2933-7H50	x 0933-7	7135	24.27	14.64	204	0.3	1.4	84.9	3.4
2931-20H50	x 0931-20	6565	23.17	14.15	164	1.3	4.7	85.2	2.8
CR211-7H50	x CR911-7(Sp)	7708	25.98	14.86	159	1.4	2.6	83.9	3.5
CR210-2H50	x CR910-2(Sp)	7833	27.61	14.26	150	0.8	4.8	82.6	4.0
Hybrids with C833-5CMS									
Z225-9H5	C833-5HO x RZM Z025-9	7762	24.01	16.23	180	0.4	3.0	83.6	2.8
2927-4H5	x RZM 1927-4	10096	33.04	15.30	123	2.3	3.1	84.6	4.1
2936-10H5	x RZM 0936-10	8362	26.57	15.79	198	1.4	5.7	84.6	3.1
2936-16H5	x RZM 0936-16	8049	24.82	16.20	202	0.1	5.2	83.3	3.0
2930-35H5	x RZM 1930-35	8159	24.95	16.34	181	0.5	4.4	84.0	3.5
2930-19H5	x RZM 1930-19	7616	24.98	15.26	185	0.4	2.9	84.6	3.0
2929-45H5	x 9929-45	7694	24.91	15.48	183	0.9	3.4	84.3	2.3
1929-4H5	x RZM 9929-4	8046	24.67	16.30	187	0.8	6.6	84.6	2.9
1931H5	x 9931(C)	8092	26.60	15.25	149	1.4	2.8	83.3	3.5
1941H5	x 0941	7506	24.64	15.27	169	0.9	0.3	84.6	3.6
2943H5	x %S(C)	8202	25.80	15.96	183	0.4	5.6	83.5	3.6
Z210H5	x Z#(C)	7200	21.44	16.82	191	1.1	3.2	83.3	4.6
P207/8H5	x P007/8	8151	26.56	15.46	182	1.3	6.3	83.0	2.4
Y277H5	x RZM R136-Y175(C)	8164	26.63	15.39	181	0.3	3.1	83.1	4.1
R278H5	x RZM R178	7939	25.15	15.80	177	0.6	1.6	83.8	3.8
N224H98	N165-9H50(g) x RZM-NR N124	7697	26.86	14.50	192	1.1	1.8	83.8	3.1
Mean		7722.4	25.33	15.25	188.4	0.9	4.1	84.2	3.2
LSD (.05)		903.7	2.97	0.51	14.6	1.1	5.2	1.6	0.7
C.V. (%)		11.9	11.91	3.38	7.9	131.4	129.5	2.0	22.9
F value		10.5**	9.36**	14.32**	16.7**	3.2**	1.0NS	2.0**	11.9**

NOTE: See test 2903 for performance without rhizomania.

TEST 8203. PERFORMANCE OF HYBRIDS WITH SELF-STERILE (SˢSˢ) POLLINATORS, UNDER RHIZOMANIA, SALINAS, CA, 2003

48 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: April 25, 2003
Harvested: October 15, 2003

Variety	Description	Acre Yield Sugar Lbs	Beets Tons	Sucrose %	Beets/ 100' No.	Missing Feet No.	Root Rot %	RJAP %	Powdery Mildew 10/20
Checks									
Beta 4776R	2-12-03	7272	23.78	15.27	210	0.0	0.5	86.3	1.9
Phoenix	9-16-02	6970	23.60	14.80	166	1.1	3.3	87.1	4.5
Beta 4430R	2-12-03	8220	26.61	15.48	217	0.3	2.9	87.7	2.5
Eagle	9-16-02	5807	19.18	15.14	159	1.3	3.5	84.8	3.9
Hybrids with FS lines									
R278H50	C790-15CMS x RZM-ER-% R178	7185	24.12	14.90	192	0.5	6.1	85.6	2.8
R278-2H50	x R078-2	7764	24.74	15.76	212	0.0	2.6	85.6	3.4
R278-7H50	x R078-7	6809	22.56	15.10	206	0.1	1.4	87.7	3.9
R278-14H50	x R078-14	7259	24.09	15.06	187	0.0	0.6	85.9	2.8
R278-16H50	x R078-16	7402	24.78	14.95	186	0.1	0.9	84.5	2.5
R278-27H50	x R078-27	6512	21.41	15.19	202	0.0	0.9	85.7	3.1
R278-4H50	x R078-4	7242	24.74	14.60	203	0.5	3.5	85.4	2.9
R280/2-9H50	x R080/2-9	8422	27.57	15.30	194	0.1	0.6	85.0	4.1
R280-6H50	x R080-6	8740	28.35	15.41	195	0.1	1.8	85.8	2.9
Y269-8H50	x Y069-8	7347	24.14	15.13	206	0.0	2.0	85.0	2.5
Y269-18H50	x Y069-18	7595	25.60	14.84	219	0.0	0.8	86.1	2.9
Y269-39H50	x Y069-39	8250	28.57	14.45	205	0.0	0.5	84.1	2.8
Y291H50	x RZM Y191	7118	24.75	14.40	191	0.1	0.3	84.5	3.4
R276-89H50	x RZM-% R076-89	7766	25.69	15.15	210	0.1	0.3	85.5	2.9
Y290H50	x RZM-% Y090	7688	24.99	15.35	202	0.0	2.0	84.6	3.0
Z210H50	x %S(C)	4823	16.58	14.57	198	0.1	1.1	86.1	3.9
P207/8H50	x RZM-PMR-NR P007/8	8180	27.86	14.68	200	0.0	0.6	84.7	2.3
P207/8H50	x P007/8	8450	28.79	14.68	204	0.9	3.4	84.6	2.8
P229-8H50	x P029-8	7233	23.51	15.48	192	0.1	3.8	86.0	2.8
P229-20H50	x P029-20	6332	22.70	13.93	207	0.6	5.4	86.1	3.1
P230-10H50	x P030-10	7675	24.88	15.40	208	0.4	4.4	85.8	3.0
P230-17H50	x P030-17	7690	26.12	14.71	205	0.3	0.9	86.1	3.8
Y275H50	x RZM-% Y075	7814	26.52	14.77	204	0.1	1.3	85.3	3.0
Y275-16H50	x Y075-16	7085	24.04	14.73	220	0.4	2.9	84.7	4.3

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Missing Feet No.	Root Rot %	RJAP %	Powdery Mildew 10/20
Hybrids with FS lines (cont.)									
Y267-21H50	C790-15CMS x Y067-21	7666	26.14	14.69	171	0.8	6.0	84.1	2.9
Y267-24H50	x Y067-24	7490	26.02	14.38	222	0.1	1.0	84.3	2.9
Y267-34H50	x Y067-34	6675	22.99	14.51	221	0.5	1.0	86.3	2.4
Y271-14H50	x Y071-14	8674	28.67	15.10	206	0.0	1.8	86.0	3.5
Y277H50	x RZM R136-Y175	7584	27.11	13.95	199	0.0	1.6	83.9	3.5
R243-14H50	C790-15CMS x R043-14	8297	27.94	14.86	201	0.3	0.6	85.1	2.3
Angelina	3-19-02	8458	27.06	15.63	211	0.5	2.4	85.9	6.4
R270-18H50	C790-15CMS x R070-18	7003	23.02	15.20	173	0.5	3.2	84.6	3.0
Retests									
R178-6H50	C790-15CMS x R978-6	7609	25.64	14.84	187	0.3	0.0	86.4	2.9
R180-21H50	x R980-21	8525	27.14	15.69	191	0.8	4.0	85.1	3.6
R181-22H50	x R981-22	6996	23.84	14.68	192	0.1	4.1	86.8	2.5
Y168-8H50	x Y968-8	7438	24.72	15.06	194	0.3	3.6	86.3	2.6
Y167-5H50	x Y967-5	7638	26.86	14.20	208	0.0	2.3	84.8	2.0
Hybrids with C833-5CMS									
R278-4H5	C833-5CMS x R078-4	7730	24.87	15.52	195	0.1	0.3	86.4	3.1
R280/2-9H5	x R080/2-9	8820	27.17	16.29	176	0.4	1.6	85.5	3.6
Roberta	susc.check, 3-25-03	3505	13.61	12.94	214	2.1	4.0	85.4	2.3
Z210H5	C833-5CMS x %S(C)	7481	21.92	17.05	171	0.1	1.7	84.1	4.0
P207/8H5	x P007/8	9304	29.02	16.00	188	0.3	1.5	85.0	2.5
Y277H5	x RZM R136-Y175	8630	27.91	15.50	177	0.0	1.0	83.6	3.6
R278H5	x RZM R178	7997	25.24	15.89	168	0.5	3.1	85.2	3.0
Mean		7503.5	24.94	15.02	197.1	0.3	2.2	85.4	3.1
LSD (.05)		923.2	3.04	0.64	14.5	0.7	4.1	1.8	0.7
C.V. (%)		12.5	12.37	4.34	7.5	229.6	191.1	2.1	23.1
F value		9.1**	7.47**	8.15**	8.9**	2.6**	1.2NS	2.1**	9.2**

NOTE: See test 3003 for performance without rhizomania.

A91

TEST 8303. EVALUATION OF TOPCROSS HYBRIDS UNDER RHIZOMANIA, SALINAS, CA, 2003

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: May 1, 2003
Harvested: October 21, 2003

Variety	Description	Acre Yield		Sucrose	Beets/ 100'	Missing Feet	Root Rot	RJAP	Powdery Mildew 10/20
		Sugar Lbs	Beets Tons	%	No.	No.	%	%	
Check									
Beta 4430R	9-2002	7125	21.99	16.29	214	0.4	0.0	87.0	2.1
Phoenix	9-16-02	5896	19.25	15.48	176	0.6	0.0	87.4	3.6
Topcrosses to Y91									
Y291H50	C790-15CMS x RZM Y191	7497	24.25	15.52	195	0.5	0.6	85.0	2.8
Y291H5	C833-5HO x RZM Y191	9299	28.51	16.30	178	0.4	0.3	84.1	3.1
Y291H73	01-FC123H5 x RZM Y191	8346	26.50	15.73	187	0.3	0.0	83.4	3.6
Y291H74	01-FC1014H5 x RZM Y191	8035	24.51	16.35	194	0.3	0.0	84.5	3.3
Topcrosses to R78									
R278H73	01-FC123H5 x RZM R178	7540	22.99	16.40	193	0.3	0.0	84.9	3.3
R278H74	01-FC1014H5 x RZM R178	8015	23.91	16.76	199	0.3	0.0	84.2	3.8
R278H50	C79-15CMS x RZM R178	7164	22.41	15.98	202	0.5	0.0	85.1	3.4
R278H5	1833-5HO x RZM R178	9041	27.18	16.61	173	0.5	0.4	85.9	2.8
R278H6	0833-5H50 x RZM R178	8046	24.69	16.30	197	0.0	0.0	85.6	3.4
R278H95	N165-#(g)mmaa x RZM R178	7011	23.48	14.89	177	0.5	0.0	84.7	3.8
R278H75	1835-11H5 x RZM R178	8451	25.50	16.60	191	0.1	0.0	86.1	3.5
R278H76	1835-26H5 x RZM R178	8964	27.44	16.30	178	0.3	0.0	85.7	2.4
R278H2	9831-3HO x RZM R178	7848	24.99	15.70	198	0.3	0.0	84.8	2.8
R278H27	9831-4HO x RZM R178	8760	27.89	15.73	190	0.1	0.0	85.5	4.0
R278H77	1833-5-8HO x RZM R178	8811	26.40	16.67	181	0.4	0.0	84.9	2.6
R278H78	1833-5-11HO x RZM R178	9061	26.60	17.04	170	0.5	0.0	86.5	2.9
R278H45	9867-1HO x RZM R178	7041	22.68	15.50	194	0.3	0.0	86.0	2.9
R278H46	9869-6HO x RZM R178	7008	21.73	16.10	203	0.3	0.0	85.7	4.4
R278H67	0837-6H5 x RZM R178	7649	23.69	16.14	192	0.3	0.3	85.7	3.0
Y291H23	Z025-9aa x RZM Y191	8379	24.91	16.84	206	0.1	0.0	84.4	2.4
R278H23	Z025-9aa x RZM R178	8616	25.29	17.02	208	0.0	0.0	84.7	1.8
R278H40	1930-35aa x RZM R178	8349	24.17	17.27	196	0.1	0.0	85.6	2.9

TEST 8303. EVALUATION OF TOPCROSS HYBRIDS UNDER RHIZOMANIA, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield			Beets/ 100'	Missing Feet	Root Rot	RJAP	Powdery Mildew
		Sugar Lbs	Beets Tons	Sucrose %	No.	No.	%	%	10/20
Mean		7998.0	24.62	16.23	191.3	0.3	0.1	85.3	3.1
LSD (.05)		941.4	2.79	0.50	14.2	0.6	0.5	1.6	0.7
C.V. (%)		12.0	11.50	3.12	7.5	212.6	740.6	1.9	22.7
F value		6.3**	4.81*	10.69**	5.3**	0.6NS	0.9NS	2.7**	6.2**

A93

TEST 7903. EVALUATION OF TESTCROSS HYBRIDS TO C833-5CMS UNDER RHIZOMANIA, SALINAS, CA, 2003

24 entries x 8 reps., RCB(e)
1-row plots, 22 ft. long

Planted: April 25, 2003
Harvested: October 21, 2003

Variety	Description	Acre Yield			Beets/100' No.	Missing Feet No.	Root Rot %	RJAP %	Powdery Mildew 10/20
		Sugar Lbs	Beets Tons	Sucrose %					
Checks									
Phoenix	9/16/02	7420	24.19	15.49	157	2.8	5.1	87.5	4.0
Eagle	9/16/02	6881	21.18	16.25	148	2.1	2.6	87.1	4.4
B4776R	2/12/03	10065	31.23	16.15	205	0.3	0.5	87.2	1.5
B4430R	2/12/03	7949	24.64	16.19	198	0.3	2.8	87.7	2.8
Roberta	3/25/03	2441	8.77	13.80	200	4.3	5.9	84.2	2.1
B6600	2/5/02	5436	17.36	15.74	196	1.8	4.3	86.8	3.9
Angelina	3/10/03	10011	29.55	16.99	199	0.4	1.2	85.7	2.1
B4001R	2/12/03	10485	31.08	16.92	198	0.1	0.9	86.4	1.6
Testcrosses with lines and populations									
R278H5	C833-5CMS x RZM R178	9354	28.27	16.59	171	0.6	3.8	84.9	4.1
Y291H5	x RZM Y191	9949	29.90	16.69	178	0.8	2.7	84.9	4.1
Y277H5	x RZMR136-Y175	10873	32.39	16.81	179	0.9	2.5	84.5	3.9
P207/8H5	x P007/8	10844	32.94	16.54	176	0.4	4.9	84.4	3.3
Z210H5	x PX &S Polish(C)	8940	25.09	17.89	175	0.8	2.9	84.5	4.5
Z943H5	x PX &S MM,S^f(C)	9896	29.43	16.81	182	0.5	2.7	84.6	3.6
Z125H5	x RZM Z025	9607	28.97	16.60	164	0.8	0.7	84.8	4.3
1931H5	x RZM 0931(C)	9547	29.89	16.00	149	1.1	2.4	84.3	4.0
Testcrosses with progeny lines									
R278-4H5	C833-5CMS x R078-4	10768	33.22	16.26	185	0.1	3.3	85.8	3.9
R280/2-9H5	x R080/2-9	9644	29.16	16.55	176	0.6	5.7	84.3	4.8
Z225-9H5	x RZM Z025-9	9911	29.55	16.79	180	0.6	4.1	83.8	3.3
2929-45H5	x RZM 9929-45	9892	30.05	16.46	166	0.6	0.0	86.1	3.1
2930-19H5	x RZM 1930-19	9277	28.57	16.27	173	0.6	4.5	85.2	3.4
2930-35H5	x RZM 1930-35	9731	28.69	17.01	175	0.6	1.5	84.6	3.8
2936-10H5	x RZM 0936-10	9933	29.79	16.67	173	1.0	4.1	86.2	3.8
2936-16H5	x 0936-16	9248	27.18	17.09	187	0.3	1.8	84.5	2.5
Mean		9087.6	27.55	16.44	178.8	0.9	3.0	85.4	3.4
LSD (.05)		925.7	2.87	0.49	17.6	1.4	4.3	1.8	0.9
C.V. (%)		10.3	10.58	3.02	10.0	149.6	148.2	2.1	26.6
F value		33.1**	27.63**	17.98**	6.1**	3.8**	1.2NS	3.3**	7.8**

A94

Test 6303. EVALUATION OF POPULATION HYBRIDS UNDER RHIZOMANIA, SALINAS, CA, 2003

48 entries x 4 reps, sequential
1-row plots, 11 ft. long

Planted: April 30, 2003
Harvested: November 6, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew 9/08	Powdery Mildew 9/18	Powdery Mildew 11/6	Powdery Mildew Mean
Checks											
Phoenix	9/16/02	9223	27.56	16.77	211	85.4	0.0	3.3	2.0	3.0	2.8
Beta 4776R	2/12/03	9570	28.02	17.08	232	85.7	0.0	2.8	2.0	3.8	2.3
Beta 4430R	2/12/03	8656	26.20	16.60	207	87.0	0.0	2.5	2.3	2.3	2.3
Eagle	9/16/02	7880	23.38	16.98	191	85.5	0.0	1.8	1.8	2.3	1.9
Lines and populations											
R278	RZM R178, C78/3	9471	28.02	16.90	180	85.7	0.0	3.5	3.0	4.5	3.7
R291	RZM Y191	8401	24.79	16.95	200	83.3	0.0	3.0	2.3	3.8	3.0
2931	RZM-% 0931 (A,aa)	8152	23.99	17.00	214	82.6	0.0	2.3	2.0	3.0	2.4
2941	RZM-% 0941 (A,aa)	7300	23.38	15.90	207	84.3	0.0	2.0	2.5	3.3	2.6
Z225	RZM-% Z025 (A,aa)	8569	26.61	16.17	207	83.2	1.1	3.0	2.8	3.3	3.0
2930-35	RZM 1930-35aa x A,C930-35	9178	26.37	17.42	205	83.6	0.0	3.5	2.8	4.0	3.4
Z025-9	Z825-9aa x A, CZ25-9	7743	22.19	17.42	209	81.0	0.0	2.3	1.8	1.8	1.9
CR211	RZM-% CR011 (A,aa)	10278	31.85	16.23	205	83.8	0.0	4.0	3.0	4.3	3.8
Population hybrids											
R278H31	RZM 1931(Iso)aa x RZM R178	9693	29.29	16.70	189	83.1	1.6	2.8	2.3	4.5	3.2
R278H41	RZM 1941aa x RZM R178	8478	26.53	16.02	184	83.2	0.0	2.0	2.0	4.0	2.7
R278H25	Z125aa x RZM R178	8289	24.39	17.00	198	84.4	0.0	2.5	2.5	3.8	2.9
R278H40	1930-35aa x RZM R178	9328	26.81	17.50	218	83.9	0.0	2.8	2.8	3.8	3.1
R278H23	Z025-9aa x RZM R178	10129	29.03	17.60	193	83.9	0.0	2.8	2.5	3.8	3.0
Y291H31	RZM 1931aa x RZM Y191	9254	28.02	16.52	216	83.5	0.0	2.5	2.3	3.8	2.8
Y291H41	RZM 1941aa x RZM Y191	9567	28.42	16.85	195	84.8	0.0	3.3	2.5	3.8	3.2
Y291H11	RZM CR111aa x RZM Y191	9196	27.78	16.77	218	84.3	0.0	3.5	3.0	3.8	3.4
Y291H25	RZM Z125aa x RZM Y191	9788	30.03	16.42	200	85.5	1.0	3.3	2.3	3.3	2.9
Y291H23	Z025-9aa x RZM Y191	10396	29.63	17.55	191	84.6	0.0	3.8	2.8	3.0	3.2

Test 6303. EVALUATION OF POPULATION HYBRIDS UNDER RHIZOMANIA, SALINAS, CA, 2003

(cont.)

Variety	Description	Acre Yield Sugar lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	RJAP %	Root Rot %	Powdery Mildew 9/08	Powdery Mildew 9/18	Powdery Mildew 11/6	Mean
Population hybrids (cont.)											
Y291H5	0833-5HO x RZM Y191	10454	30.24	17.33	205	84.0	0.0	3.3	2.5	4.0	3.3
Y291H50	C790-15CMS x RZM Y191	8933	26.81	16.67	211	84.1	2.1	2.5	2.3	4.0	2.9
R278H5	C833-5HO x RZM R178	10761	31.65	17.08	189	85.8	0.0	3.3	2.5	4.5	3.4
R278H50	C790-15CMS x RZM R178	7334	21.97	16.67	225	85.5	0.0	3.0	2.5	4.8	3.4
R278H96	N165HO (w/o g) x RZM R178	9718	28.83	16.88	202	84.0	0.0	3.3	2.8	4.8	3.6
R278H97	N167HO (w/o g) x RZM R178	9318	27.62	17.05	198	85.6	1.2	4.0	2.8	3.5	3.4
R278H56	1836HO x RZM R178	8320	25.00	16.65	186	85.7	0.0	5.0	3.5	5.0	4.5
R278H42	C842HO(A) x RZM R178	8917	28.42	15.65	193	83.7	0.0	4.5	2.8	4.3	3.8
R278H55	1835HO x RZM R178	9858	30.84	15.98	200	84.6	0.0	3.8	2.8	4.5	3.7
R278H70	C869HO x RZM R178	9587	30.03	16.00	195	84.4	0.0	4.3	3.3	3.8	3.8
Checks											
Beta 4001R	9-2002	9772	30.64	16.10	207	84.0	0.0	4.0	2.5	2.0	2.8
Angelina	3/19/02	10291	30.03	17.20	200	86.0	1.1	6.8	5.5	6.0	6.1
Z210 polycross											
Z210H5	0833-5HO x Z10(C)	9066	24.39	18.60	184	84.0	0.0	4.3	3.3	4.3	3.9
Z210H50	C790-15CMS x Z10(C)	5561	17.74	16.00	207	84.6	1.0	4.3	3.8	5.0	4.3
Z210	Inc. Z010(C)	4579	14.57	16.00	200	85.8	1.0	4.8	4.0	3.8	4.2
Z210-1	Z011 x Z010(C)	5682	15.92	17.95	200	85.0	1.1	5.0	3.8	4.0	4.3
Z210-2	Z012 x Z010(C)	6884	18.95	18.17	200	84.5	0.0	5.0	4.3	4.5	4.6
Z210-3	Z013 x Z010(C)	5739	16.55	17.63	182	85.9	0.0	4.8	3.5	4.3	4.2
Z210-4	Z014 x Z010(C)	4618	13.30	17.52	195	84.4	0.0	4.3	2.8	3.8	3.6
Z210-7	Z017 x Z010(C)	5581	15.52	17.95	205	84.6	1.1	5.0	4.0	4.3	4.4
943 &S line polycross											
2943-9	RZM Z025-9aa x 943C	8839	25.20	17.58	191	83.1	0.0	2.8	2.8	2.8	2.8
2943-35	1930-35aa x 943C	10796	31.45	17.23	193	84.6	0.0	3.5	2.8	4.0	3.4

A96

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/ 100' | RJAP | Root Rot | Powdery Mildew | | | |
		Sugar Lbs	Beets Tons	%	No.	%	%	9/08	9/18	11/6	Mean
943 %S line polycross (cont.)											
2943-19	1930-19aa x 943C	9443	27.41	17.27	202	84.8	0.0	1.5	2.0	2.8	2.1
2943-14	RZM Z131-14aa x 943C	9374	27.01	17.33	198	84.9	0.0	2.8	2.8	3.8	3.1
2943-20	RZM Z131-20aa x 943C	9212	26.81	17.25	195	83.9	0.0	2.8	1.8	2.0	2.2
2943H5	0833-5HO x 943(C)	10767	30.64	17.67	184	83.6	0.0	2.8	2.5	4.3	3.2
Mean		8707.1	25.83	16.95	200.3	84.4	0.3	3.4	2.8	3.7	3.3
LSD (.05)		2305.7	7.23	1.06	26.1	2.2	1.5	1.0	0.9	1.1	0.7
C.V. (%)		18.9	20.02	4.45	9.3	1.8	410.1	20.9	24.2	20.5	15.2
F value		3.7**	3.42**	3.03**	1.4NS	2.0**	1.0NS	8.5**	4.7**	5.4**	9.9**

NOTE: See test 3803 for performance without rhizomania.

TEST 6403-2. EVALUATION OF HYBRIDS WITH DUAL RESISTANCE TO SBCN & RHIZOMANIA, SALINAS, CA, 2003

12 entries x 8 reps., RCB
1-row plots, 11 ft. long

Planted: April 7, 2003
Harvested: November 6, 2003

Variety	Genotype	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Root Rot %	RJAP %	Powdery Mildew 9/08	9/18	11/6	Mean
Checks												
Angelina	R_1Rz_2,nn	3/10/03	10432	29.63	17.60	191	0.0	85.7	4.3	3.4	2.5	3.4
Beta 4430	Rz1,nn	2/12/03	9543	28.52	16.80	199	0.0	86.4	3.1	2.9	2.9	3.0
Roberta	rzrz,nn	3/25/03	4969	16.74	15.01	195	0.0	86.9	3.0	2.8	2.8	2.8
R278H5	Rz1,nn	C833-5HO x RZM R178	11175	31.85	17.49	183	0.0	85.3	3.6	3.1	5.0	3.9
Nematode resistant hybrids												
Hil-1	Rz,N	4/22/03 Syngenta	8641	27.28	15.86	186	0.0	84.4	3.9	2.9	3.3	3.3
Hil-2	Rz,N	4/22/03 Syngenta	9738	31.34	15.54	198	0.6	84.4	3.3	2.9	3.9	3.3
Hil-3	rzrz,N	4/22/03 Syngenta	5038	18.19	13.88	181	0.6	84.1	3.1	2.3	2.9	2.8
R278H95	Rz1,N:nn	N165-#(g)aa x R178	9467	29.90	15.82	182	0.0	83.1	3.5	2.9	3.8	3.4
R278H96	Rz1,N:nn	N165HO x R178	9162	27.31	16.79	195	0.0	84.2	4.1	3.3	4.5	4.0
N224H98	Rz1,N	N165-9H50(g) x RZM-NR N124	9272	29.20	15.89	178	0.0	84.9	3.3	2.4	2.5	2.7
N224(C)H94	Rz1,N	N165-9HO(g) x N124-#(C)(g)	9275	28.88	16.11	191	0.0	84.7	3.8	3.0	3.3	3.3
N112	Rz1,WB242	NR-RZM P912(A,aa)	8262	25.50	16.21	182	0.0	84.2	2.4	1.5	2.3	2.0
Mean			8747.9	27.03	16.08	188.4	0.1	84.9	3.4	2.8	3.3	3.2
LSD (.05)			1963.8	6.15	0.63	14.2	0.7	1.7	1.0	0.9	0.9	0.7
C.V. (%)			22.6	22.85	3.93	7.6	697.5	2.0	29.6	33.0	26.6	22.0
F value			7.5**	4.84**	21.42**	2.1*	0.9NS	3.1**	2.1*	2.5*	7.6**	4.8**

Notes: Machine harvested so no attempt was made to score rhizomania or SBCN. Test was grown adjacent to 6403-1 where rhizomania and SBCN infestation was moderate.

N = *Hs pro-1* in heterozygous or segregating pattern. N:nn is known to segregate for *Hs*.

TEST 7803. WESTERN SUGAR, MICHIGAN SUGAR, SOUTHERN MINN.BSC, & USDA HYBRID EVALUATION UNDER RHIZOMANIA, SALINAS, CA, 2003

48 entries x 8 reps, RCB
1-row plots, 22 ft. long

Planted: April 25, 2003
Harvested: October 27 and November 3, 2003

Variety	Sugar Yield Sugar (Lbs)	Sugar Yield Beets (Tons)	Sucrose %	Stand Count No.	Harv Count No.	Beets/ 100' No.	Miss Feet No.	Root Rot %	RJAP %	Powdery Mildew Score	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)	Canopy (Foliar) Score
Checks & Calif. Comm. Hybrids													
Beta 4776R	9611	29.23	16.48	47	45	214	0.0	1.1	85.9	1.3	3.43	82.4	1.0
Phoenix	8371	25.72	16.34	37	32	169	1.6	1.1	86.0	4.4	3.75	73.5	1.3
Rizor	8729	25.72	17.01	40	38	180	0.4	1.5	83.9	5.0	3.75	71.7	1.3
Roberta	3252	11.35	14.49	45	31	203	1.3	4.2	84.3	3.4	5.34	5.8	3.0
Beta 4430R	9707	28.50	17.10	46	43	209	0.5	0.9	85.9	3.0	3.37	84.3	1.6
Angelina	10281	28.83	17.86	47	46	213	0.0	1.1	85.9	1.6	3.13	93.2	1.0
Eagle	7715	23.04	16.76	35	32	157	0.9	0.8	83.7	4.3	3.92	65.4	1.1
US H11	4089	14.26	14.18	47	37	214	1.0	5.7	82.7	5.3	5.32	9.9	3.0
Western Sugar Entries													
Monohikari	4118	13.43	15.19	44	35	200	1.4	2.2	85.2	4.8	5.37	8.0	2.9
HM1653Rz(Syngenta)	8222	24.32	16.91	42	41	191	0.0	0.3	84.3	3.9	3.24	88.6	1.3
C R243 (Crystal)	8558	23.66	18.11	44	44	201	0.0	0.0	82.7	5.8	3.30	89.7	1.1
SX0225 (Seedex)	7158	21.18	16.93	42	38	189	0.5	2.2	85.4	4.6	4.35	46.3	2.8
HM7172Rz(Syngenta)	8628	23.61	18.42	45	43	202	0.0	0.7	82.8	2.3	3.23	91.5	1.0
HM7206Rz(Syngenta)	8388	23.12	18.27	43	39	195	0.6	7.6	84.5	1.5	3.79	70.8	1.5
Monohikari(Seedex)	4681	15.54	15.07	45	33	206	2.4	7.0	85.2	4.6	5.54	2.7	3.0
HM-E17	4345	13.57	15.99	45	33	204	2.3	5.7	84.9	4.6	5.53	6.3	3.0
Michigan Sugar Entries													
HM 2761Rz	9010	25.28	17.88	45	43	206	0.0	0.3	83.4	3.1	3.31	86.3	1.1
BK 1381R	8411	22.86	18.48	42	40	189	0.3	0.6	84.2	4.5	3.42	85.4	1.0
VDH 03HX323	5425	16.79	16.20	45	31	206	1.0	11.9	86.3	4.6	5.58	2.8	3.0
HM 2763Rz	7351	20.36	18.16	43	40	195	0.1	1.5	84.7	3.3	3.60	78.7	1.4
VDH 46526	7095	19.07	18.73	46	43	209	0.3	3.4	83.8	4.4	3.38	89.0	1.4
C R351	6165	17.66	17.58	43	39	194	0.5	1.2	84.2	5.4	4.16	53.7	1.8

(cont.)

Variety	Sugar Yield Sugar (Lbs)	Sugar Yield Beets (Tons)	Sucrose %	Stand Count No.	Harv Count No.	Beets/100' No.	Miss Feet No.	Root Rot %	RJAP %	Powdery Mildew Score	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)	Canopy (Foliar) Score
Michigan Sugar Entries (cont.)													
HM 2769Rz	7139	19.07	18.77	47	44	211	0.3	2.0	83.1	3.5	3.35	84.1	1.1
SX 1230	6281	18.12	17.29	44	40	199	0.0	1.9	83.9	3.9	4.51	39.4	1.5
BK 1383R	8722	24.37	18.00	46	44	207	0.3	0.0	83.2	4.9	3.68	72.8	1.0
HH-135	5947	15.99	18.61	36	28	164	3.3	5.6	83.1	3.6	4.10	63.1	2.0
HM 7172Rz	9376	25.43	18.46	47	44	212	0.3	1.6	84.5	3.1	3.24	91.0	1.0
C R353	5707	16.36	17.48	47	40	212	0.4	4.4	83.9	3.9	4.87	20.4	1.8
BK 1384R	8732	24.69	17.81	43	41	195	0.0	0.0	86.0	3.5	3.79	73.8	1.3
VDH 03HX317 (47153)	5835	14.96	19.65	33	29	151	2.3	1.5	84.6	3.3	3.91	70.3	1.9
HM 2771Rz	8610	23.26	18.59	44	41	199	0.3	2.9	84.3	2.6	3.32	85.5	1.4
C R359	9166	26.54	17.33	45	43	205	0.3	1.3	84.7	1.8	3.42	81.5	1.4
BK 1382R	7989	21.92	18.31	45	44	205	0.1	0.3	83.5	4.9	3.75	70.8	1.6
HM 2770Rz	8344	21.80	19.14	48	46	218	0.0	0.0	81.8	3.4	3.19	91.0	1.1
H 02HX272	6676	17.35	19.38	36	32	164	1.1	2.7	83.8	3.5	3.80	80.1	1.6
HM E17 (susc ck)	3647	11.61	15.77	46	40	210	0.5	0.0	84.1	4.5	5.50	4.4	2.9
Southern Minnesota Beet Sugar Cooperative													
Crystal 999	4400	13.54	16.25	44	37	200	0.1	2.1	84.2	5.3	5.53	7.1	2.8
Hilleshog 2445Rz	7964	21.44	18.64	40	38	184	0.4	1.1	84.6	3.4	3.34	83.6	1.4
Betaseed 4811R	8686	23.96	18.24	44	42	201	0.1	1.3	84.5	4.5	3.39	87.1	1.0
Beta 3820	5470	16.58	16.56	41	34	185	1.8	5.1	83.8	4.9	5.45	7.7	2.9
Vander Have 46177R	7767	20.19	19.30	32	30	147	2.0	0.0	84.3	4.0	3.69	76.8	1.6
Crystal R932	7235	18.95	19.11	43	43	193	0.1	0.3	82.8	2.9	3.92	63.5	1.4
Beta 4930R	9309	25.23	18.44	42	41	191	0.1	1.1	84.8	2.6	3.30	90.4	1.0
Beta 4575RR	8737	23.32	18.80	44	44	198	0.0	0.0	84.6	4.8	3.33	88.6	1.3
VDH 46140	7319	18.89	19.36	33	30	151	1.3	0.0	83.4	4.1	3.72	81.2	1.1
HM-E17	3601	11.55	15.61	44	34	198	0.6	4.0	82.9	4.1	5.57	4.8	2.9

TEST 7803. WESTERN SUGAR, MICHIGAN SUGAR, SOUTHERN MINN.BSC, & USDA HYBRID EVALUATION UNDER RHIZOMANIA, SALINAS, CA, 2003

(cont.)

| Variety | Sugar Yield | | Sucrose | Stand Count | Harv Count | Beets/ 100' | Miss Feet | Root Rot | RJAP | Powdery Mildew | Rhizomania Resistance | | Canopy (Foliar) |
	Sugar Lbs	Beets Tons	%	No.	No.	No.	No.	%	%	Score	DI	%R(0-4)	Score
USDA Entries													
2930-35H5	8389	23.12	18.19	40	39	184	0.1	0.9	84.5	4.6	3.30	90.9	1.1
2930-19H5	8911	25.99	17.17	39	38	178	0.3	0.0	84.7	3.3	3.32	91.3	1.0
Mean	7276.5	20.65	17.55	42.7	38.5	194.0	0.6	2.1	84.2	3.8	4.0	62.2	1.7
LSD (.05)	1153.8	3.27	0.61	3.5	5.3	15.9	1.1	4.7	1.7	0.7	0.3	11.6	0.4
C.V. (%)	16.1	16.10	3.52	8.3	14.0	8.3	168.8	229.1	2.1	19.4	7.8	19.0	22.7
F value	20.4**	17.05**	37.71**	10.1**	7.1**	10.1**	4.2**	2.1**	2.6**	16.3**	58.8**	60.2**	29.2**

NOTES:
Tests were planted into moist beds and emerged without irrigation. Very little damping-off or plant loss was observed and stands were very good. Irrigation was lightly applied by sprinkler until after thinning when normal rates were used to increase incidence and severity of rhizomania. During the core growing season, irrigation was done every 4-5 days. Conditions for disease development were good. Growth, foliar symptoms and root scores suggested that test 7803-2 (reps 5-8) was more severe than 7803-1 (reps 1-4). Tests were analyzed as two 4-replication tests and as one 8-replication test. Other than noted below, other diseases and pests did not appear to be a problem or differentially affect yield or rhizomania. In addition to BNYVV, ELISA tests also showed that BOLV (*Beet oak leaf virus*) was present. BNYVV was A-type. The plots were hand harvested, individual roots scored for rhizomania, and placed in two sample bags for clean-tared weight and % sugar analyses.

Rust & Downey Mildew: These diseases occurred early but did not appear to significantly influence results as they did in the non-rhizomania March plantings.

Aphanomyces: Some roots showed evidence of possible *Aphanomyces* infection. At harvest, a few were fangy and showed infection scars and lesions. Some varieties were more affected than others.

Harvest count: Number of roots counted and scored per plot. An average of 320 roots were scored for each entry.

Beets/100 ft: Number of plants per 100 ft. of row, counted post thinning.

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(cont.)

| Variety | Sugar Yield | | Sucrose | Stand Count | Harv Count | Beets/ 100' | Miss Feet | Root Rot | RJAP | Powdery Mildew | Rhizomania Resistance | Canopy (Foliar) |
	Sugar Lbs	Beets Tons	%	No.	No.	No.	No.	%	%	Score	DI %R(0-4)	Score

Root Rot %: Frequency of roots with noticeable root rot, most caused by *Sclerotium rolfsii*, the cause of Southern rot. Rotted roots were scored for rhizomania when possible, included in gathered beets for weighing, but were discarded prior to running samples through the sugar lab.

Powdery Mildew Score: Mildew was controlled until late in the season. Just prior to harvest, powdery mildew was scored on a scale of 0 to 9, where 9 = 90-100% of leaf area covered. Even though scores were moderately high, powdery mildew would have had little overall influence on sugar yield.

RJAP = raw juice apparent purity = (% sucrose/ %soluble solids)100.

Foliar score: Just prior to harvest, plots were rated for color, where 1 = resistant = normal green color; 2 = segregating for foliar color at any ratio or frequency, due to any reason; 3 = susceptible = yellowed or yellowish due to rhizomania or any reason including genotype, other diseases, nutrition, etc.

Rhizomania Scores: All 8 reps were hand harvested and scored. Reps 1-4 on 11/03/03 & reps 5-8 on 10/27/03. After being lifted, the roots were hand shaken to remove soil and laid out. Each individual root was scored on a scale of 0 to 9, where 9 is most severe. Roots scored 0 to 4 were considered resistant and 5 to 9 were susceptible. Most resistant roots were scored as 3's and most susceptible ones as 5's. Following scoring all beets were topped and placed into two sample bags. After washing, the samples were run through the sugar lab.

The reaction to rhizomania was moderate in Test 7803-1 and moderately-severe in 7803-2. Based upon foliage color (yellowing), rhizomania was a factor in susceptible plants even when the tap root did not show full susceptibility.

Missing Feet: At harvest, plots were measured for missing feet. Because initial stands were generally very good, most missing feet were due to root rot and loss caused by *Sclerotium rolfsii*. Only roots or plants too severely damaged to be included in the harvested score or weight were included in this calculation. It was obvious that most of the damage due to *S.rolfsii* was to weaker, rhizomania susceptible plants and plots. Harvested plot weights were adjusted for missing ft. of row.

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TEST 7803. WESTERN SUGAR, MICHIGAN SUGAR, SOUTHERN MINN.BSC, & USDA HYBRID EVALUATION UNDER RHIZOMANIA, SALINAS, CA, 2003

(cont.)

| | Sugar Yield | | Stand Count | Harv Count | Beets/ 100' | Miss Feet | Root Rot | RJAP | Powdery Mildew | Rhizomania Resistance | | Canopy (Foliar) |
Variety	Sugar Lbs	Beets Tons	No.	No.	No.	No.	%	%	Score	DI	%R(0-4)	Score %S

Coefficients of correlation (r) were calculated:

	% Resist	HC	SY	RY	Foliar Score	Missing Feet	%S
Disease Index	-0.98**	-0.34**	-0.79**	-0.69**	0.81**	0.29**	-0.56**
% Resistant		0.32**	0.79**	0.69**	-0.81**	-0.25**	0.57**
Harvest Count			0.24**	0.20**	-0.35**	-0.68**	0.16***
Sugar Yield				0.97**	-0.70**	-0.13*	0.37***
Root Yield					-0.63**	-0.09NS	0.14*
Foliar Score						0.31**	-0.12*
Missing Feet							

Entries: Entries 10-15 were received coded from Western Sugar Company. Entries 17-36 were received coded from Michigan Sugar Industry. Entries 37-45 were received coded from Southern Minnesota Beet Sugar Company. Other entries were resistant and susceptible checks added by USDA. Susceptible checks included Roberta, US H11, Monohikari, and HM-E17. Resistant checks included Beta 4776R, Phoenix, Rizor, Beta 4430R, Angelina, Eagle, 2930-35H5, and 2930-19H5.

TEST 7703. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA, 2003

Planted: April 25, 2003
Harvested: October 29 & November 5, 2003

96 entries (73 CBGA + 23 USDA) x 8 reps, RCB
1-row plots, 22 ft. long

| Code No. | Variety | Sugar Yield | | Sucrose | Stand Count | Harv Count | Beets/ 100' | Miss Feet | Root Rot | RJAP | Powdery Mildew | Rhizomania Resistance | | Canopy (Foliar) |
		Sugar Lbs	Beets Tons	%	No.	No.	No.	No.	%	%	Score	DI	%R(0-4)	Score
CBGA entries														
1	1GK7429	9741	30.08	16.23	44	37	198	0.3	2.5	87.3	1.5	3.1	93.1	1.1
2	1GK0062	11148	32.71	17.11	45	42	204	0.0	1.7	87.7	1.3	3.1	97.1	1.1
3	02HX237R	9193	29.57	15.68	47	40	212	0.5	2.7	88.0	5.3	3.4	89.3	1.5
4	03HX304	9341	27.11	17.28	44	43	201	0.0	0.6	85.6	5.1	3.3	87.8	1.0
5	02HX241	8612	26.28	16.53	45	48	203	0.5	3.4	86.4	4.8	3.3	90.0	1.8
6	Beta 4200R	10412	31.03	16.76	47	44	214	0.0	0.5	87.2	1.1	3.1	94.2	1.4
7	03HX309	12633	43.39	14.60	14	10	62	10.0	0.0	85.2	4.3	3.4	96.3	1.0
8	03HX308	10686	32.35	16.64	37	34	169	0.9	0.0	85.9	2.1	3.2	90.9	1.4
9	HH 142	10047	30.24	16.69	43	42	197	0.0	0.0	86.2	3.3	3.3	89.8	1.1
10	CrystalR062	10324	29.88	17.28	47	47	215	0.1	0.5	87.4	2.8	3.0	92.6	1.8
11	02HX243	9896	29.36	16.92	42	40	190	0.0	0.6	85.5	3.8	3.2	90.6	1.1
12	01HX002	6739	19.37	17.44	44	39	199	1.1	2.9	86.2	5.4	4.1	57.0	1.6
13	02HX245	8279	26.42	15.68	43	38	197	0.3	1.4	87.6	4.6	3.5	77.6	1.8
14	03HX316	9314	30.11	15.49	38	36	170	0.5	0.0	87.2	5.6	3.0	94.6	1.6
15	03HX305	9979	32.27	15.46	44	43	202	0.5	1.1	86.6	5.4	3.4	85.5	1.5
16	03HX317	9900	30.87	16.08	48	42	218	1.1	6.6	84.8	2.6	3.5	84.0	1.4
17	03HX360	8957	28.39	15.89	46	42	209	0.6	5.0	86.6	2.9	3.1	94.4	1.8
18	9GK7014	11815	34.06	17.45	46	43	207	0.3	4.2	86.7	1.6	2.9	98.0	1.1
19	HH 145	8231	23.63	17.52	38	35	174	0.5	0.9	86.0	4.4	3.4	86.1	1.3
20	1GK0052	11515	33.32	17.34	47	44	215	0.4	2.5	86.8	1.3	3.3	86.5	1.3
21	Acclaim	9358	25.85	18.13	46	43	207	0.1	1.5	86.8	4.9	3.5	83.9	1.4
22	03HX318	7838	23.47	16.77	46	44	210	0.0	0.8	83.9	5.4	4.2	54.4	1.6
23	01HX016	9136	26.37	17.33	44	42	198	0.3	0.0	85.7	5.4	3.2	92.7	1.1
24	9J0158	8306	24.92	16.76	45	42	203	0.1	0.2	86.9	4.6	3.7	69.7	2.0

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Code No.	Variety	Sugar Yield Sugar Lbs	Sugar Yield Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	Beets/ 100' No.	Miss Feet No.	Root Rot %	RJAP %	Powdery Mildew Score	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)	Canopy (Foliar) Score
CBGA entries (cont.)														
25	1GK7425	9635	30.03	16.12	47	46	214	0.0	0.0	87.6	2.3	3.3	86.1	1.1
26	02HX229R	10275	28.62	17.97	45	43	204	0.3	0.0	87.8	4.6	3.1	95.8	1.3
27	02HX220	9245	27.11	17.12	43	43	194	0.1	0.0	88.0	4.3	3.5	79.9	2.0
28	2GK6097	9307	26.76	17.56	50	47	227	0.0	2.3	86.1	2.1	3.3	84.8	1.3
29	Falcon	9485	26.74	17.76	46	44	209	0.1	0.0	87.9	5.0	3.3	87.3	1.1
30	2GK6080	11307	31.94	17.72	53	50	241	0.1	1.1	87.8	1.9	2.9	96.1	1.1
31	03HX311	9618	28.21	17.04	43	41	197	0.1	0.0	85.8	3.3	3.5	80.2	1.4
32	03HX301	8950	27.22	16.51	43	41	196	0.3	0.3	87.3	3.5	3.6	77.2	1.6
33	9GK7003	11407	33.91	16.86	48	45	220	0.4	2.1	87.0	1.8	2.9	97.0	1.3
34	9GK1705	5093	17.03	14.98	45	41	202	0.4	0.6	86.6	5.6	4.5	39.3	2.5
35	02HX242	9273	27.06	17.22	47	42	214	1.1	4.5	87.2	4.4	3.3	88.7	2.0
36	1GK0005	9991	28.54	17.61	51	48	231	0.4	3.9	87.3	1.5	3.2	89.9	1.3
37	Raptor	8606	26.72	16.17	52	41	234	2.0	7.9	87.4	3.8	3.4	87.0	1.8
38	03HX302	8877	26.63	16.77	46	43	210	0.0	1.0	87.3	4.3	3.5	83.1	1.8
39	Eagle	9138	27.62	16.72	46	43	210	0.4	2.8	87.0	4.0	3.4	85.3	1.5
40	Phoenix	9715	30.20	16.33	47	42	211	0.8	0.8	87.7	4.5	3.5	80.3	1.4
41	Alpine	8892	27.39	16.42	45	42	204	0.4	1.4	87.8	3.9	3.4	85.5	2.0
42	03HX307	8904	29.36	15.27	45	43	204	0.1	1.9	85.7	4.3	3.5	78.0	1.3
43	03HX321	7078	21.82	16.24	50	47	227	0.1	0.2	85.1	5.3	4.3	48.6	1.9
44	02HX247	9725	26.95	18.08	46	45	207	0.3	1.0	87.0	4.8	3.3	87.4	1.4
45	03HX314	8488	23.83	17.85	42	39	190	0.4	0.3	86.1	4.6	3.6	77.4	1.4
46	Beta 4430R	10788	31.54	17.11	49	48	224	0.0	0.0	88.5	2.6	2.8	96.5	1.4
47	9J0159	9142	27.11	16.91	47	44	215	0.3	1.0	87.3	4.8	3.5	81.8	1.6
48	03HX313	10784	29.73	18.16	44	44	200	0.0	0.6	86.3	3.0	3.1	91.9	1.1

(cont.)

Code No.	Variety	Sugar Yield		Sucrose %	Stand Count No.	Harv Count No.	Beets/ 100' No.	Miss Feet No.	Root Rot %	RJAP %	Powdery Mildew Score	Rhizomania Resistance		Canopy (Foliar) Score
		Sugar Lbs	Beets Tons									DI	%R(0-4)	
CBGA entries (cont.)														
49	02HX212R	7342	20.37	18.07	49	44	221	0.0	0.0	83.6	4.4	3.8	72.0	1.5
50	0GK1642	10333	30.44	17.01	47	44	212	0.1	0.0	87.1	3.4	3.1	93.8	1.1
51	Beta 4300R	8220	23.55	17.54	47	45	213	0.0	0.5	86.4	5.0	3.4	84.0	1.4
52	02HX204	9811	29.43	16.77	45	40	202	0.6	1.4	87.1	4.9	3.3	87.8	1.8
53	03HX322	8377	22.94	18.28	46	44	209	0.0	0.0	87.0	4.6	3.5	81.3	1.1
54	1GK7409	9597	30.98	15.61	41	38	188	0.3	1.2	86.4	1.9	3.3	84.0	1.4
55	01HX004	8816	27.86	15.91	55	46	251	0.4	0.9	87.5	3.0	3.1	94.3	1.5
56	CrystalR241	9501	31.52	15.11	47	45	212	0.1	0.0	87.1	1.5	3.3	81.0	1.1
57	Beta 4001R	10633	30.34	17.55	50	48	227	0.0	0.0	88.2	1.5	3.0	94.4	1.3
58	03HX310	10663	31.57	16.91	41	39	184	0.4	0.0	85.7	5.1	2.8	99.3	1.0
59	02HX219	8908	24.95	17.92	41	39	187	0.3	0.0	84.6	4.3	3.6	77.0	1.5
60	03HX306	9509	26.20	18.17	41	38	187	0.3	2.2	85.9	4.6	3.4	80.9	1.4
61	03HX315	7456	22.46	16.51	34	30	156	2.5	0.6	86.6	4.1	3.6	79.7	2.1
62	1GK0054	12427	35.98	17.28	45	41	202	0.1	0.0	87.8	2.0	2.9	96.1	1.3
63	02HX218	9056	25.13	18.04	40	38	181	0.1	0.3	85.2	4.4	3.4	83.6	1.1
64	00HX052	9020	27.59	16.39	44	43	202	0.1	0.3	86.6	4.9	3.5	78.3	1.6
65	02HX202	8196	25.57	16.09	44	40	200	0.0	0.0	86.5	5.8	3.4	86.5	1.0
66	03HX303	8986	24.93	18.08	44	43	201	0.0	1.9	85.5	4.5	3.2	96.2	1.1
67	Us H11	3641	14.09	13.01	50	42	228	1.0	2.4	84.4	6.4	5.0	21.8	2.8
68	Beta 4440R	7628	24.99	15.42	49	47	223	0.0	1.0	86.9	5.5	3.4	82.7	1.4
69	1GK7458	10606	33.24	16.10	48	45	216	0.0	0.0	87.2	1.8	3.3	86.5	1.3
70	9J5382	9911	29.01	17.16	48	46	216	0.1	0.8	86.9	2.4	3.1	88.5	1.3
71	Beta 4776R	9602	29.28	16.46	52	49	237	0.0	0.7	87.0	1.8	3.3	85.5	1.4
72	1J0263	11279	34.26	16.47	47	46	213	0.1	0.0	87.4	2.4	3.0	90.6	1.3
73	SSN-NB7R	8174	26.19	15.60	40	38	184	0.3	0.0	86.8	4.9	3.6	79.0	1.3

TEST 7703. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA, 2003

(cont.)

Code No.	Variety	Sugar Yield Sugar Lbs	Sugar Yield Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	Beets/100' No.	Miss Feet No.	Root Rot %	RJAP %	Powdery Mildew Score	Rhizomania Resistance DI	Rhizomania Resistance %R(0-4)	Canopy (Foliar) Score
USDA entries														
74	US H11	4682	17.09	13.69	46	40	207	0.6	3.0	85.9	5.9	4.6	37.0	2.6
75	Roberta	4926	17.33	14.11	47	37	215	0.5	3.9	85.7	2.6	4.9	26.7	2.5
76	B6600	5926	18.03	16.37	45	40	206	0.6	4.6	86.8	4.8	5.0	27.6	2.8
77	Angelina	11138	31.53	17.72	48	48	218	0.3	0.6	85.8	1.4	3.1	96.1	1.0
78	Rizor	8363	23.94	17.54	47	43	211	0.4	1.8	85.4	4.8	3.6	75.8	1.4
79	Y277H5	11072	32.31	17.16	42	40	190	0.1	0.0	85.2	4.0	3.0	95.6	1.3
80	P207/8H5	11307	32.22	17.59	42	39	193	0.3	1.1	85.2	2.9	3.2	93.6	1.0
81	1927-4H5	10685	30.59	17.48	43	40	194	0.5	1.9	83.7	4.9	3.0	96.9	1.4
82	Z210H5	8665	23.80	18.25	42	39	190	1.1	5.0	84.8	4.4	3.4	82.1	1.8
83	Z210H50	6224	19.08	16.41	45	36	203	0.4	5.4	87.2	4.5	4.6	38.8	2.5
84	US H11	4301	15.88	13.62	52	39	234	1.1	2.6	84.8	5.8	4.8	30.1	2.8
85	Rizor	8629	24.75	17.43	47	44	214	0.0	0.7	85.6	4.8	3.6	76.7	1.5
86	Angelina	10781	30.45	17.69	49	47	222	0.1	2.9	86.1	1.5	3.1	97.3	1.1
87	B6600	5823	17.80	16.31	48	43	220	0.1	2.0	86.6	4.9	4.9	28.7	2.4
88	Roberta	4570	16.05	14.13	50	39	229	0.6	2.0	84.6	2.9	5.1	17.2	2.9
89	2930-19H5	10241	30.73	16.68	44	43	199	0.1	0.6	86.0	4.0	3.1	94.8	1.0
90	2930-35H5	10100	27.64	18.27	42	38	189	0.6	2.7	86.6	4.5	3.1	97.4	1.0
91	2929-45H5	10003	28.89	17.34	41	38	186	0.4	4.1	85.1	2.8	2.8	98.7	1.0
92	Y275H50	8775	26.72	16.48	46	43	207	0.1	1.9	86.2	4.1	3.7	69.4	1.6
93	VDH46140	7763	20.12	19.38	38	34	172	1.4	1.6	85.7	4.1	3.7	77.0	1.4
94	Z225-9H5	9291	26.27	17.77	42	41	192	0.1	0.7	84.6	3.1	3.0	97.5	1.5
95	R278H95	8550	27.30	15.76	41	38	185	0.4	1.2	84.9	4.3	3.4	83.4	1.3
96	R278H5	9409	27.68	17.04	38	35	172	0.4	2.8	85.6	3.1	3.3	89.8	1.3
Mean		9104.6	27.21	16.74	44.8	41.5	203.8	0.5	1.5	86.4	3.8	3.5	81.0	1.5
LSD (.05)		1073.6	3.45	0.68	4.6	5.3	21.0	0.9	3.8	1.8	0.7	0.4	12.2	0.5
C.V. (%)		12.0	12.90	4.15	10.5	13.1	10.5	196.1	265.9	2.1	20.0	10.4	15.3	31.4
F value		20.5**	15.64**	21.10**	8.6**	6.6**	8.6**	12.0**	1.4*	2.7**	25.7**	16.9**	19.0**	7.5**

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TEST 7703.   CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA, 2003

(cont.)

Code No.	Variety	Sugar Yield		Sucrose %	Stand Count No.	Harv Count No.	Beets/100' No.	Miss Feet No.	Root Rot RJAP %	Powdery Mildew Score	Rhizomania Resistance DI %R(0-4)	Canopy (Foliar) Score
		Sugar Lbs	Beets Tons									

NOTES:

Tests were planted into moist beds and emerged without irrigation. Very little damping-off or plant loss was observed and stands were very good. Irrigation was lightly applied by sprinkler until after thinning when normal rates were used to increase incidence and severity of rhizomania. During the core growing season, irrigation was done every 4-5 days. Conditions for disease development were good. Growth, foliar symptoms and root scores suggested that test 7703-2 (reps 5-8) was more severe than 7703-1 (reps 1-4). Tests were analyzed as two 4-replication tests and as one 8-replication test. Other than noted below, other diseases and pests did not appear to be a problem or differentially affect yield or rhizomania. In addition to BNYVV, ELISA tests also showed that BOLV (Beet oak leaf virus) was present. BNYVV was A-type. The plots were hand harvested, individual roots scored for rhizomania, and placed in two sample bags for clean-tared weight and % sugar analyses.

Rust & Downey Mildew: These diseases occurred early but did not appear to significantly influence results as they did in the non-rhizomania March plantings.

Aphanomyces: Some roots showed evidence of possible Aphanomyces infection. At harvest, a few were fangy and showed infection scars and lesions. Some varieties were more affected than others.

Harvest count: Number of roots counted and scored per plot. An average of 320 roots were scored for each entry.

Beets/100 ft: Number of plants per 100 ft. of row, counted post thinning.

Root Rot %: Frequency of roots with noticeable root rot, most caused by Scelerotium rolfsii, the cause of Southern rot. Rotted roots were scored for rhizomania when possible, included in gathered beets for weighing, but were discarded prior to running samples through the sugar lab.

Powdery Mildew Score: Mildew was controlled until late in the season. Just prior to harvest, powdery mildew was scored on a scale of 0 to 9, where 9 = 90-100% of leaf area covered. Even though scores were moderately high, powdery mildew would have had little overall influence on sugar yield.

RJAP = raw juice apparent purity = (% sucrose/ %soluble solids)100.

Foliar score: Just prior to harvest, plots were rated for color, where 1 = resistant = normal green color; 2 = segregating for foliar color at any ratio or frequency, due to any reason, due to rhizomania or any reason including genotype, other diseases, nutrition, etc.

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(cont.)

Code No.	Variety	Sugar Yield		Sucrose %	Stand Count No.	Harv Count No.	Beets/100' No.	Miss Feet No.	Root Rot %	RJAP %	Powdery Mildew Score	Rhizomania Resistance		Canopy (Foliar) Score
		Sugar Lbs	Beets Tons									DI	%R(0-4)	

Rhizomania Scores: All 8 reps were hand harvested and scored. Reps 1-4 on 11/05/03 & reps 5-8 on 10/29/03. After being lifted, the roots were hand shaken to remove soil and laid out. Each individual root was scored on a scale of 0 to 9, where 9 is most severe. Roots scored 0 to 4 were considered resistant and 5 to 9 were susceptible. Most resistant roots were scored as 3's and most susceptible ones as 5's. Following scoring all beets were topped and placed into two sample bags. After washing, the samples were run through the sugar lab.

The reaction to rhizomania was moderate in Test 7703-1 and moderately-severe in 7703-2. Based upon foliage color (yellowing), rhizomania was a factor in susceptible plants even when the tap root did not show full susceptibility.

Missing Feet: At harvest, plots were measured for missing feet. Because initial stands were generally very good, most missing feet were due to root rot and loss caused by Sclerotium rolfsii. Only roots or plants too severely damaged to be included in the harvested score or weight were included in this calculation. It was obvious that most of the damage due to S.rolfsii was to weaker, rhizomania susceptible plants and plots. Harvested plot weights were adjusted for missing ft. of row.

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Coefficients of correlation (r) were calculated:

	% Resist	HC	SY	RY	Foliar Score	Missing Feet	%S
Disease Index	-0.96**	-0.15**	-0.73**	-0.65**	0.56**	0.10*	-0.35**
% Resistant		0.10*	0.75**	0.67**	-0.58**	-0.04NS	0.37**
Harvest Count			0.07NS	0.02NS	-0.04NS	-0.67**	0.12**
Sugar Yield				0.95**	-0.55**	0.01NS	0.26**
Root Yield					-0.49**	0.08*	0.04NS
Foliar Score						0.07*	-0.28**
Missing Feet							-0.17**

Entries: Entries 1-73 were received as part of the official Rhizomania Coded Variety Trial for 2003. In addition, entries 74-96 were added as supplemental susceptible and resistant checks and as USDA fillers. Susceptible checks included US H11, Roberta, B6600 & Z210H50. Resistant checks included Angelina & Rizor.

TEST 7703. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA, 2003

(cont.)

Code No.	Variety	Sugar Yield Sugar lbs	Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	Beets/100' No.	Miss Feet No.	Root Rot %	RJAP %	Powdery Mildew Score	Rhizomania Resistance DI	%R(0-4)	Canopy (Foliar) Score

USDA entries

Code No.	Variety	Description
74	US H11	susc. ck., 10/14/02
75	Roberta	susc. ck., 3/25/03
76	B6600	susc. ck., 2/5/02
77	Angelina	resist.ck., 3/10/03
78	Rizor	resist.ck., 3/29/01
79	Y277H5	0833-5HO x RZM R136-Y175
80	P207/8H5	0833-5HO x P007/8
81	1927-4H5	0833-5HO x C927-4
82	Z210H5	0833-5HO x Polish %S(C)
83	Z210H50	C790-15CMS x Polish %S(C)
84	US H11	susc. ck., 10/14/02
85	Rizor	resist.ck., 3/29/01
86	Angelina	resist.ck., 3/10/03
87	B6600	susc.ck., 2/5/02
88	Roberta	susc.ck., 3/25/03
89	2930-19H5	0833-5HO x RZM 1930-19
90	2930-35H5	0833-5HO x RZM 1930-35
91	2929-45H5	0833-5HO x RZM 9929-45
92	Y275H50	C790-15CMS x RZM-% Y075
93	VDH46140	susc.ck., 2003
94	Z225-9H5	1833-5HO x RZM Z025-9
95	R278H95	N165-#gaa x RZM Y178
96	R278H5	1833-5HO x RZM Y178

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TEST B103. EVALUATION OF EXPERIMENTAL HYBRIDS, IMPERIAL VALLEY, CA, 2002-2003

24 entries x 8 reps., RCB(E)
1-row plots, 18 ft. long

Planted: September 18, 2002
Harvested: June 2, 2003

| Variety | Description | | | Acre Yield | | Sucrose | Beets/100' | Bolters | Clean Beets | NO3-N |
				Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Checks										
Beta 4430R	8-31-01			14274	41.22	17.29	174	0.0	91.6	116
Phoenix	8-16-01			12586	39.67	15.81	172	0.0	94.9	169
Topcrosses to C78										
R278H50	C790-15CMS	x	RZM R178	11303	34.65	16.29	164	0.0	92.9	109
R278H5	C833-5CMS	x	"	11637	35.96	16.22	167	0.0	93.3	114
R278H6	0833-5H50	x	"	11045	34.32	16.08	161	0.0	92.5	110
R278H73	01-FC123H5	x	"	10568	32.76	16.18	164	0.4	91.6	100
R278H74	01-FC1014H5	x	"	10158	31.04	16.38	156	0.0	90.6	96
R278H95	N165-#(g)aa	x	"	9513	31.68	15.06	155	0.4	94.0	138
R278H62	0836-1H5	x	"	11586	35.78	16.20	166	0.0	92.1	80
R278H63	0836-7H5	x	"	11935	35.98	16.60	151	0.0	93.5	89
R278H64	0834-2H5	x	"	10540	33.86	15.59	165	0.0	91.0	112
R278H67	0837-6H5	x	"	10239	32.74	15.64	167	0.4	92.7	140
R278H75	1835-11H5	x	"	11516	34.61	16.65	168	0.4	93.5	99
R278H76	1835-26H5	x	"	11183	34.17	16.39	147	1.8	92.7	145
R278H2	9831-3HO	x	"	10913	32.82	16.61	154	0.0	92.7	81
R278H27	9831-4HO	x	"	11653	37.18	15.62	171	0.0	91.0	98
R278H28	0831-4-7HO	x	"	11327	35.38	16.00	160	0.0	90.8	87
R278H29	0831-4-10HO	x	"	12076	37.97	15.98	158	0.0	90.1	97
R278H77	1833-5-8HO	x	"	11403	33.55	16.99	154	0.0	92.1	85
R278H78	1833-5-11HO	x	"	11390	33.64	16.91	159	0.0	93.4	87

TEST B103. EVALUATION OF EXPERIMENTAL HYBRIDS, IMPERIAL VALLEY, CA, 2002-2003

(cont.)

Variety	Description		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean
Topcrosses to C78 (cont.)									
R278H45	9867-1HO	x "	10300	32.09	16.03	157	0.8	90.5	85
R278H46	9869-6HO	x "	9913	30.90	16.01	165	0.0	91.9	91
R278H23	Z025-9Maa	x "	10873	31.89	17.06	158	0.0	91.8	96
R278H40	1930-35Maa	x RZM R178	10896	32.96	16.52	157	0.0	92.9	99
Mean			11201.0	34.45	16.26	161.2	0.2	92.3	105.1
LSD (.05)			1183.7	3.50	0.74	41.5	0.7	2.0	50.8
C.V. (%)			10.7	10.30	4.64	9.5	433.2	2.2	49.0
F value			5.3**	4.33**	3.88**	1.7**	2.3**	2.8**	1.6NS

TEST B203. EVALUATION OF HYBRIDS WITH SELF-STERILE (S'S') POLLINATORS, IMPERIAL VALLEY, CA, 2002-2003

Planted: September 18, 2002
Harvested: June 2, 2003

48 entries x 8 reps., RCB(E)
1-row plots, 18 ft. long

Variety	Description		Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
Checks									
Beta 4001R	9/25/01		13573	40.52	16.78	165	0.0	90.9	102
Phoenix	8/16/01		12887	39.32	16.41	166	0.0	93.3	143
Beta 4430R	8-31-01		14201	40.78	17.41	170	0.0	87.0	67
Eagle	9/16/02		10557	31.09	16.93	143	0.0	92.2	100
Hybrids with FS lines									
R278H50	C790-15CMS	x RZM-ER-% R178	12001	36.17	16.58	163	2.0	91.6	71
R278-2H50		x R078-2	11507	34.19	16.84	167	0.0	91.2	73
R278-7H50		x R078-7	10169	32.21	15.79	166	0.0	90.3	109
R278-14H50		x R078-14	8643	27.62	15.62	168	0.0	86.7	47
R278-16H50		x R078-16	11108	33.94	16.41	158	0.0	89.7	59
R278-27H50		x R078-27	10745	31.78	16.88	158	0.0	88.5	51
R278-4H50		x R078-4	11840	37.56	15.70	158	0.0	91.0	97
R280/2-9H50		x R080/2-9	11632	35.07	16.65	169	0.0	90.4	71
R280-6H50		x R080-6	12544	37.10	16.99	155	0.0	91.8	70
Y269-8H50		x Y069-8	10893	32.80	16.60	152	0.0	90.0	58
Y269-18H50		x Y069-18	11195	33.75	16.60	149	0.0	90.9	75
Y269-39H50		x Y069-39	10741	32.70	16.42	162	0.0	88.6	76
Y291H50		x RZM Y191	11254	34.12	16.51	152	1.8	91.5	40
R276-89H50		x RZM-% R076-89	11930	35.82	16.66	163	0.0	91.5	57
Y290H50		x RZM-% Y090	11436	34.01	16.81	154	0.0	90.6	45
Z210H50		x %S(C)	7873	24.11	16.30	161	0.4	89.5	28
P207/8H50		x RZM-PMR-NR P007/8	11714	36.04	16.28	161	0.0	89.3	33
P207/8H50		x P007/8	12029	36.49	16.48	160	0.4	90.7	47
P229-8H50		x P029-8	11249	33.46	16.82	154	1.0	90.1	44
P229-20H50		x P029-20	10081	31.24	16.14	162	0.4	90.0	30

(cont.)

Variety	Description		Acre Yield Sugar Lbs	Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean
Hybrids with FS lines (cont.)									
P230-10H50	C790-15CMS	x P030-10	10686	32.55	16.41	155	0.4	89.8	57
P230-17H50		x P030-17	10444	32.05	16.29	158	0.0	89.0	45
Y275H50		x RZM-% Y075	10388	32.36	16.04	160	0.0	90.4	55
Y275-16H50		x Y075-16	10026	30.27	16.55	163	0.0	88.7	38
Y267-21H50		x Y067-21	11725	34.57	16.97	151	0.0	91.4	51
Y267-24H50		x Y067-24	10499	32.71	16.02	154	0.0	88.8	47
Y267-34H50		x Y067-34	11600	35.10	16.52	152	0.0	90.5	58
Y271-14H50		x Y071-14	10661	33.04	16.14	170	0.0	88.3	26
Y277H50		x RZM R136-Y175	10668	32.75	16.25	149	1.5	91.3	43
R243-14H50	C790-15CMS	x R043-14	13822	40.12	17.23	156	1.8	91.1	43
Angelina	3/19/02		11707	33.93	17.27	162	0.0	91.5	65
2930-35H50	C790-15CMS	x RZM 1930-35	11705	34.77	16.82	164	0.0	91.6	49
Retests									
Y167-5H50	C790-15CMS	x Y967-5	10475	32.03	16.37	161	0.4	89.5	26
Y168-8H50		x Y968-8	12520	37.39	16.79	158	0.0	91.2	70
Y168-16H50		x Y968-16	11982	35.38	16.93	146	0.0	90.5	32
2930-19H50		x RZM 1930-19	13154	39.11	16.82	161	0.0	91.0	38
R278H5	C833-5CMS	x RZM R178	11356	33.06	17.21	154	0.0	92.1	33
R278-4H5		x R078-4	11998	35.50	16.91	147	0.0	91.0	64
R280/2-9H5		x R080/2-9	11506	34.05	16.90	155	0.0	90.8	49
Y291H5		x RZM Y191	11479	34.15	16.82	148	0.0	92.0	53
Z210H5		x %S(C)	9039	26.28	17.22	161	0.0	87.7	38
P207/8H5		x P007/8	12360	36.95	16.75	141	0.0	94.2	37
Y277H5		x RZM R136-Y175	11363	33.50	16.96	156	0.4	90.8	33
2930-19H5		x RZM 1930-19	11967	35.22	16.97	162	0.0	91.1	39

TEST B203. EVALUATION OF HYBRIDS WITH SELF-STERILE (S'S') POLLINATORS, IMPERIAL VALLEY, CA, 2002-2003

(cont.)

| | | Acre Yield | | | Beets/ | | Clean | |
| | | Sugar | Beets | Sucrose | 100' | Bolters | Beets | NO3-N |
Variety	Description	Lbs	Tons	%	No.	%	%	Mean
Mean		11352.8	34.14	16.62	157.9	0.2	90.5	55.9
LSD (.05)		1176.4	3.47	0.62	14.0	0.9	2.8	43.0
C.V. (%)		10.5	10.30	3.76	9.0	399.8	3.1	78.1
F value		8.1**	6.97**	3.39**	1.9*	2.8**	2.2**	2.4**

TEST B303. EVALUATION OF HYBRIDS WITH S_1 PROGENY LINE POLLINATORS, IMPERIAL VALLEY, CA, 2002-2003

48 entries x 8 reps., RCB(E)
1-row plots, 18 ft. long

Planted: September 18, 2002
Harvested: June 3 & 4, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean
Checks								
Eagle	9/16/02	12374	37.67	16.38	159	0.0	91.0	105
Beta 4430R	8/31/01	15775	46.23	17.10	174	0.0	89.8	83
Phoenix	8/16/01	12973	41.35	15.72	162	0.4	92.5	166
Beta 4001R	9/25/01	14273	43.48	16.43	163	0.0	89.4	76
Retests & new seed productions								
Z025-9H50	C790-15CMS x Z825-9	10384	30.69	16.95	158	0.0	89.0	86
0930-19H50	x 8930-19	12873	38.77	16.64	170	0.4	88.3	54
2930-19H50	x RZM 1930-19	13161	41.05	16.06	153	0.0	90.6	89
1927-4H50	x RZM 9927-4	11090	34.88	15.90	159	0.4	87.9	71
1929-62H50	x RZM 9929-62	13425	41.79	16.01	161	0.0	90.4	88
2930-35H50	x RZM 1930-35	11505	34.85	16.52	167	0.0	89.9	82
1929-4H50	x RZM 9929-4	11716	34.82	16.81	158	0.0	87.7	65
1924-2H50	x RZM 9924-2	12319	39.13	15.74	151	0.0	87.2	106
2936-10H50	x RZM 0936-10	12793	38.60	16.57	169	0.5	90.3	83
2936-16H50	x RZM 0936-16	10047	30.51	16.42	164	0.0	88.2	45
2929-45H50	x 9929-45	13479	40.42	16.68	165	1.7	89.3	90
0929-112H50	x 8929-112	12527	36.54	17.15	171	0.8	89.9	55
1931-201H50	x 9931-201	13329	39.35	16.92	156	0.0	88.4	42
2942H50	x RZM-% 0942	11704	35.75	16.36	170	0.0	88.8	53
2943H50	x %S(C)	11770	34.87	16.86	160	0.0	88.4	42
2933H50	x RZM-% 9933	11322	36.00	15.72	165	0.0	88.7	71
1931H50(Sp)	x 9931(C)	12199	37.20	16.44	148	0.4	90.1	72
1941H50	x 0941	12037	36.60	16.43	153	0.0	87.4	62
Z125H50	x Z025(C)	11957	36.25	16.47	166	0.5	88.4	58
Angelina		12554	36.44	17.23	162	0.0	89.3	77

TEST B303. EVALUATION OF HYBRIDS WITH S$_1$ PROGENY LINE POLLINATORS, IMPERIAL VALLEY, CA, 2002-2003

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | Bolters | Clean Beets | NO3-N |
		Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Selected S$_1$ lines								
	C790-15CMS							
2931-3H50	x 0931-3	12770	38.00	16.85	175	0.0	87.0	36
2941-20H50	x 0941-20	12706	36.76	17.32	154	0.0	89.2	38
2933-14H50	x 0933-14	12452	36.69	16.96	167	0.0	89.4	67
2933-17H50	x 0933-17	12886	36.76	17.54	153	0.0	87.9	46
2933-7H50	x 0933-7	11511	35.81	16.03	154	0.0	88.2	84
Hybrids with C833-5CMS								
	C833-5CMS							
1931H5	x 9931(C)	12250	37.66	16.32	152	0.0	90.5	75
1941H5	x 0941	12283	36.55	16.82	156	0.0	88.0	55
Z125H5	x Z025(C)	10857	31.81	17.08	153	0.0	89.5	58
Z225-9H5	x RZM Z025-9	11397	34.03	16.74	160	0.0	88.4	55
2927-4H5	x RZM 1927-4	12606	37.77	16.69	134	0.0	88.8	61
2936-10H5	x RZM 0936-10	13322	40.83	16.31	163	0.0	92.6	50
2936-16H5	x RZM 0936-16	9692	27.32	17.76	158	0.0	86.4	22
2930-35H5	x RZM 1930-35	11239	32.99	17.01	154	0.0	89.5	47
2930-19H5	x RZM 1930-19	11949	36.46	16.43	160	0.0	90.1	52
2929-45H5	x 9929-45	13080	38.85	16.89	163	0.0	89.8	51
1929-62H5	x RZM 9929-62	13350	40.49	16.49	168	0.0	90.0	68
1929-4H5	x RZM 9929-4	13054	37.27	17.54	143	0.0	91.3	49
1924-2H5	x RZM 9924-2	11839	34.19	17.32	158	0.0	89.9	54
2943H5	x %S(C)	11297	33.30	16.99	160	0.0	90.3	59
Z210H5	x Z#(C)	9624	28.25	17.00	149	0.0	86.6	45
P207/8H5	x P007/8	11949	36.89	16.15	156	0.0	89.1	42
Y277H5	x RZM R136-Y175(C)	11773	35.99	16.37	151	0.8	90.0	54
R278H5	C833-5CMS x RZM R178	13028	38.39	17.03	134	0.0	91.5	45
N224H98	N165-9H50(g) x RZM-NR N124	10417	32.30	16.17	158	0.0	84.8	29

A117

TEST B303. EVALUATION OF HYBRIDS WITH S$_1$ PROGENY LINE POLLINATORS, IMPERIAL VALLEY, CA, 2002-2003

(cont.)

| | | Acre Yield | | | Beets/ | | Clean | |
Variety	Description	Sugar Lbs	Beets Tons	Sucrose %	100' No.	Bolters %	Beets %	NO3-N Mean
Mean		12185.8	36.64	16.65	158.7	0.1	89.2	63.8
LSD (.05)		1401.0	4.16	0.69	15.3	0.6	2.0	44.7
C.V. (%)		11.7	11.54	4.22	9.8	485.2	2.3	71.1
F value		5.3**	5.85**	3.86**	2.5**	2.2**	4.4**	226.9**

A118

TEST B403. EVALUATION OF HYBRIDS WITH S$_1$ PROGENY LINE POLLINATORS UNDER RHIZOMANIA,
IMPERIAL VALLEY, CA, 2002-2003

48 entries x 8 reps., RCB(E)　　　　　　　　　　　　Planted:　September 18, 2002
1-row plots, 18 ft. long　　　　　　　　　　　　　　Harvested:　June 3, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean
Checks								
Eagle	9/16/02	5889	18.30	16.25	161	0.0	93.4	237
Beta 4430R	8/31/01	8995	27.29	16.59	171	0.0	93.5	172
Phoenix	8/16/01	7541	24.87	15.15	167	0.0	94.2	273
Beta 4001R	9/25/01	8368	25.69	16.38	155	0.0	91.8	174
Retests & new seed productions								
Z025-9H50	C790-15CMS x Z825-9	5985	18.20	16.63	163	0.0	91.4	161
0930-19H50	x 8930-19	6088	19.03	16.11	161	0.0	90.7	111
2930-19H50	x RZM 1930-19	5174	16.68	15.68	170	0.0	90.5	143
1927-4H50	x RZM 9927-4	8743	28.67	15.21	159	0.0	90.4	209
1929-62H50	x RZM 9929-62	6443	21.02	15.47	156	0.0	91.5	207
2930-35H50	x RZM 1930-35	5620	17.32	16.31	169	0.0	92.3	140
1929-4H50	x RZM 9929-4	6702	19.62	17.16	165	0.0	93.2	127
1924-2H50	x RZM 9924-2	6834	21.26	16.13	161	0.0	91.5	167
2936-10H50	x RZM 0936-10	7104	21.64	16.53	174	0.0	91.5	130
2936-16H50	x RZM 0936-16	4408	13.76	16.28	165	0.0	90.9	137
2929-45H50	x 9929-45	6951	22.20	15.74	160	0.0	92.2	140
0929-112H50	x 8929-112	7043	20.83	17.01	158	0.0	90.2	113
1931-201H50	x 9931-201	7141	22.95	15.48	161	0.0	90.5	134
2942H50	x RZM-% 0942	6458	21.18	15.26	152	0.5	91.0	137
2943H50	x %S(C)	6084	18.17	16.78	158	0.0	90.1	111
2933H50	x RZM-% 9933	6137	19.89	15.51	159	0.0	90.9	147
1931H50(Sp)	x 9931(C)	6679	21.03	15.82	149	0.0	91.8	148
1941H50	x 0941	5816	18.06	16.05	152	0.0	90.9	137
Z125H50	x Z025(C)	6153	20.79	14.84	163	0.0	93.2	134
Angelina		6551	20.81	15.65	151	0.0	89.3	167

TEST B403. EVALUATION OF HYBRIDS WITH S$_1$ PROGENY LINE POLLINATORS UNDER RHIZOMANIA,
IMPERIAL VALLEY, CA, 2002-2003

(cont.)

Variety	Description		Acre Yield		Sucrose	Beets/100'	Bolters	Clean Beets	NO3-N
			Sugar Lbs	Beets Tons	%	No.	%	%	Mean
Selected S$_1$ lines									
	C790-15CMS								
2931-3H50		x 0931-3	6396	19.69	16.21	161	0.0	89.0	88
2941-20H50		x 0941-20	4513	13.94	16.16	167	0.0	89.4	131
2933-14H50		x 0933-14	6165	18.10	16.97	162	0.0	92.0	90
2933-17H50		x 0933-17	7424	22.76	16.28	137	0.0	91.8	126
2933-7H50		x 0933-7	7665	23.30	16.36	157	0.0	90.7	101
Hybrids with C833-5CMS									
1931H5	C833-5CMS	x 9931(C)	5167	16.81	15.36	140	0.0	90.5	101
1941H5		x 0941	5929	18.22	16.36	128	0.0	91.4	110
Z125H5		x Z025(C)	5760	17.69	16.31	146	0.0	92.4	122
	C833-5CMS								
Z225-9H5		x RZM Z025-9	5897	17.51	17.00	163	0.0	90.4	94
2927-4H5		x RZM 1927-4	10593	33.97	15.56	135	0.0	93.7	142
2936-10H5		x RZM 0936-10	5679	16.55	17.14	154	0.0	93.1	102
2936-16H5		x RZM 0936-16	4836	14.21	17.07	159	0.0	92.0	95
2930-35H5		x RZM 1930-35	6587	19.45	16.96	152	0.0	91.4	114
2930-19H5		x RZM 1930-19	5730	18.40	15.68	151	0.0	92.3	114
2929-45H5		x 9929-45	6401	19.75	16.27	154	0.0	98.1	129
1929-62H5		x RZM 9929-62	8069	25.34	15.98	153	0.0	92.4	156
1929-4H5		x RZM 9929-4	7169	20.47	17.59	145	0.0	92.3	91
1924-2H5		x RZM 9924-2	6196	18.62	16.68	152	0.0	92.9	136
2943H5		x %S(C)	5648	16.70	16.93	157	0.0	91.5	101
Z210H5		x Z#(C)	5778	16.39	17.77	156	0.4	90.0	71
P207/8H5		x P007/8	8330	26.63	15.69	149	0.0	92.3	99
Y277H5		x RZM R136-Y175(C)	8660	27.82	15.57	151	0.4	93.6	116
R278H5		x RZM R178	7106	21.06	16.81	145	0.0	92.5	105
N224H98	N165-9H50(g)	x RZM-NR N124	7028	22.31	15.76	149	0.0	85.3	135

A120

TEST B403. EVALUATION OF HYBRIDS WITH S₁ PROGENY LINE POLLINATORS UNDER RHIZOMANIA,
IMPERIAL VALLEY, CA, 2002-2003

(cont.)

Variety	Description	Acre Yield			Beets/		Clean	NO3-N
		Sugar	Beets	Sucrose	100'	Bolters	Beets	Mean
		Lbs	Tons	%	No.	%	%	
Mean		6617.3	20.52	16.22	155.9	0.03	91.6	133.8
LSD (.05)		1414.8	4.40	0.69	17.7	0.32	3.2	47.1
C.V. (%)		21.7	21.79	4.35	11.5	1156.4	3.5	35.7
F value		5.6**	6.47**	7.20**	2.2**	0.94NS	2.5**	5.3**

A121

TEST B503. EVALUATION OF HYBRIDS WITH SELF-STERILE (S^{s}S^s) POLLINATORS UNDER RHIZOMANIA,
IMPERIAL VALLEY, CA, 2002-2003

48 entries x 8 reps., RCB(E)
1-row plots, 18 ft. long

Planted: September 18, 2002
Harvested: June 5 & 6, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean	Root Rot %
Checks									
Beta 4001R	9/25/01	7695	24.26	16.00	175	0.0	89.8	258	0.0
Phoenix	8/16/01	6692	22.99	14.53	172	0.0	92.5	286	0.0
Beta 4430R	8-31-01	9752	29.63	16.47	179	0.0	92.8	183	0.0
Eagle	9/16/02	6267	20.84	15.09	162	0.0	92.4	313	0.0
Hybrids with FS lines									
R278H50	C790-15CMS x RZM-ER-% R178	4130	12.81	16.16	163	0.0	89.3	206	0.0
R278-2H50	x R078-2	4667	14.42	16.23	175	0.0	89.4	156	0.0
R278-7H50	x R078-7	4475	14.32	15.31	174	0.0	87.6	199	0.0
R278-14H50	x R078-14	4977	15.69	15.82	165	0.0	86.8	174	0.0
R278-16H50	x R078-16	5802	18.20	15.86	169	0.0	87.9	173	0.0
R278-27H50	x R078-27	4808	15.27	15.80	162	0.0	89.6	134	0.4
R278-4H50	x R078-4	5471	18.04	15.05	171	0.0	88.9	275	0.0
R280/2-9H50	x R080/2-9	5117	15.92	16.17	163	0.0	88.2	153	0.0
R280-6H50	x R080-6	6637	21.38	15.64	172	0.0	90.3	189	0.0
Y269-8H50	x Y069-8	5236	16.75	15.49	169	0.0	89.8	214	0.0
Y269-18H50	x Y069-18	4035	13.43	14.98	165	0.0	88.3	215	0.0
Y269-39H50	x Y069-39	6947	22.49	15.52	165	0.0	91.7	186	0.0
Y291H50	x RZM Y191	6368	21.23	14.97	174	0.0	90.7	199	0.0
R276-89H50	x RZM-% R076-89	4603	14.11	16.07	168	0.0	91.3	171	0.0
Y290H50	x RZM-% Y090	4789	14.82	16.13	159	0.0	88.3	167	0.4
Z210H50	x %S(C)	4687	13.44	17.62	171	0.0	88.7	137	0.0
P207/8H50	x RZM-PMR-NR P007/8	6796	22.56	14.94	174	0.0	90.2	145	1.1
P207/8H50	x P007/8	7425	24.86	14.86	172	0.4	92.4	193	0.0
P229-8H50	x P029-8	4951	15.51	15.79	154	0.4	89.6	147	0.0
P229-20H50	C790-15CMS x P029-20	5207	16.02	16.14	172	0.0	88.8	160	0.0

TEST B503. EVALUATION OF HYBRIDS WITH SELF-STERILE (s's*) POLLINATORS UNDER RHIZOMANIA, IMPERIAL VALLEY, CA, 2002-2003

(cont.)

Variety	Description	Acre Yield		Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean	Root Rot %
		Sugar Lbs	Beets Tons						
Hybrids with FS lines (cont.)									
P230-10H50	C790-15CMS x P030-10	5407	16.80	15.86	165	0.0	87.9	218	0.0
P230-17H50	x P030-17	5170	15.95	16.16	166	0.0	88.5	185	0.0
Y275H50	x RZM-% Y075	6865	22.94	14.97	174	0.0	91.0	188	0.0
Y275-16H50	x Y075-16	5591	18.72	14.88	177	0.0	90.4	221	0.0
Y267-21H50	x Y067-21	7896	25.28	15.69	155	0.0	91.6	193	0.0
Y267-24H50	x Y067-24	7038	23.49	14.99	167	0.0	92.1	210	0.0
Y267-34H50	x Y067-34	5219	17.22	15.07	166	0.0	90.7	191	0.0
Y271-14H50	x Y071-14	6656	21.48	15.58	160	0.0	91.4	171	0.0
Y277H50	x RZM R136-Y175	7516	25.51	14.67	156	0.4	92.4	235	0.5
R243-14H50	C790-15CMS x R043-14	8246	27.32	14.98	159	0.0	92.1	205	0.0
Angelina	3/19/02	6366	20.32	15.60	166	0.0	87.7	208	0.0
2930-35H50	C790-15CMS x RZM 1930-35	4377	13.44	16.03	163	0.0	91.4	199	0.0
Retests									
Y167-5H50	C790-15CMS x Y967-5	7032	23.16	15.16	163	0.0	92.6	146	0.4
Y168-8H50	x Y968-8	5945	17.72	16.85	168	0.0	90.5	149	0.0
Y168-16H50	x Y968-16	4934	14.90	16.73	157	0.0	89.7	132	0.0
2930-19H50	C790-15CMS x RZM 1930-19	4784	15.00	16.11	153	0.0	88.7	156	0.0
R278H5	C833-5CMS x RZM R178	5579	17.65	15.81	147	0.0	91.3	171	0.0
R278-4H5	x R078-4	5481	17.17	15.87	174	0.0	88.8	182	0.0
R280/2-9H5	x R080/2-9	5529	17.32	15.85	159	0.0	89.5	156	0.0
Y291H5	x RZM Y191	6842	22.16	15.44	156	0.0	92.6	167	0.0
Z210H5	x %S(C)	5059	14.33	17.61	159	0.0	87.7	103	0.0
P207/8H5	x P007/8	8138	26.49	15.35	161	0.0	98.7	145	0.0
Y277H5	x RZM R136-Y175	7404	24.58	15.05	153	0.0	92.4	187	0.0
2930-19H5	C833-5CMS x RZM 1930-19	4544	14.66	15.29	172	0.0	90.2	195	0.0

TEST B503. EVALUATION OF HYBRIDS WITH SELF-STERILE ($s^s s^s$) POLLINATORS UNDER RHIZOMANIA,
IMPERIAL VALLEY, CA, 2002-2003

(cont.)

Variety Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean	Root Rot %
Mean	5940.6	19.01	15.67	165.5	0.03	90.3	186.3	0.1
LSD (.05)	1357.3	4.35	0.80	13.9	3.35	3.4	56.6	0.5
C.V. (%)	23.2	23.25	5.21	8.5	3.77	3.8	30.8	811.3
F value	6.8**	7.99**	5.55**	2.2*	2.95**	3.0**	4.0**	1.4NS

A124

TEST B603. PROGENY PERFORMANCE UNDER RHIZOMANIA, IMPERIAL VALLEY, CA, 2002-2003

96 entries x 2 reps., sequential
1-row plots, 18 ft. long

Planted: September 18, 2002
Harvested: June 9, 2003

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean	Appear Score Mean
Checks									
Beta 4430R	8/31/01	7947	22.89	17.17	159	0.0	91.8	148	3.2
Angelina	3/19/02	5127	17.59	14.56	161	0.0	88.7	337	3.0
Phoenix	8/16/01	5485	19.45	14.23	137	0.0	92.2	413	3.2
Us H11	11/3/99	3843	14.44	13.32	156	0.0	90.4	408	3.9
99-C31/6	Inc. F86-31/6 (C31/6)	3815	12.37	15.43	153	0.0	94.6	133	3.2
Y292	Inc. Fs(C), Cycle 1, Syn 1	5456	17.92	14.97	156	0.0	90.0	253	2.2
Y275	RZM-% Y075	6946	23.21	14.97	148	3.7	91.4	253	2.2
1927-4H5	C833-5CMS x RZM 9927-4	6674	23.81	13.98	170	0.0	92.8	240	2.5
1931	0931aa x A	2983	10.42	14.32	156	0.0	91.7	338	2.5
0747	Inc. 7747 (A,aa)	3540	12.47	14.37	145	0.0	86.2	261	3.5
01-C37	Inc. U86-37	1632	5.56	14.68	145	0.0	89.5	249	4.0
R136	RZM-ER-% R936, (C79-8)	5963	21.43	13.93	142	0.0	91.3	284	2.2
F₂ lines (pair crosses) of C37 x R36)									
2236 -1- 1	1236-1(PX)	2005	7.88	12.75	122	0.0	90.5	387	2.7
-1- 2		2463	9.99	12.33	131	0.0	89.1	234	2.7
2236 -2-11	1236-2(PX)	1758	6.20	14.00	159	0.0	85.6	142	3.7
-2-12		1521	6.08	12.52	153	0.0	89.7	257	3.7
2236 -3-21	1236-3(PX)	2525	9.55	13.27	150	0.0	91.7	293	2.8
-3-22		3587	13.45	13.22	142	0.0	87.9	311	2.7
2236 -4-31	1236-4(PX)	2818	10.10	13.88	145	0.0	92.8	234	2.9
-4-32		4465	17.02	13.11	164	0.0	93.8	282	2.7
-4-33		3200	11.89	13.43	139	0.0	91.2	225	2.9
2236 -5-41	1236-5(PX)	3921	14.58	13.55	139	0.0	89.7	201	2.7
-5-42		920	3.71	12.39	139	0.0	80.7	278	4.2
-5-43		833	3.44	12.12	134	0.0	88.7	465	4.2

A125

TEST B603. PROGENY PERFORMANCE UNDER RHIZOMANIA, IMPERIAL VALLEY, CA, 2002-2003

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean	Appear Score Mean
F₂(S₁) lines of popn-747 x R36									
2237	-1- 1 1237-1⊗	1328	4.51	14.79	156	0.0	88.6	331	4.0
	-1- 2	1573	5.74	13.63	148	0.0	82.4	427	4.2
	-1- 3	922	3.90	11.84	142	0.0	89.4	647	5.0
	-1- 4	1867	6.18	15.12	145	0.0	91.1	333	4.2
	-1- 5	2013	6.60	14.66	245	0.0	87.6	150	4.7
	-1- 6	1471	5.50	13.38	139	0.0	90.9	272	4.5
2237	-2-11 1237-2⊗	1252	4.49	13.96	112	0.0	84.7	216	4.0
	-2-12	2079	6.94	14.97	128	0.0	76.2	166	3.5
2237	-2-13 1237-2⊗	2753	11.48	12.26	136	0.0	87.8	244	2.3
	-2-14	0.00	0.00	--.--	139	-.-	--.-	---	4.5
	-2-15	3166	11.80	13.39	126	0.0	87.2	141	3.0
R136	RZM-ER-8 R936, (C79-8)	5487	20.80	13.28	125	0.0	92.5	256	2.7
2237	-3-21 1237-3⊗	3659	13.25	13.97	125	0.0	92.4	242	2.9
	-3-22	1036	3.40	15.26	139	0.0	87.7	99	4.2
	-3-23	4105	15.38	13.47	153	0.0	90.7	198	3.0
	-3-24	2607	9.16	14.22	153	0.0	90.1	165	3.0
2237	-4-31 1237-4⊗	1487	6.14	12.35	170	0.0	91.2	190	4.0
	-4-32	4306	17.77	12.20	164	0.0	90.6	400	2.7
2237	-5-41 1237-5⊗	1114	3.71	15.00	139	0.0	85.3	138	4.4
	-5-42	4729	17.15	14.00	134	0.0	88.5	101	3.4
F₂(S₁) lines of popn-931 x R36									
2235	-1- 1 1235-1⊗	3737	16.42	11.42	134	0.0	92.7	465	3.2
	-1- 2	3296	12.75	13.02	134	0.0	88.6	352	3.7
	-1- 3	5223	20.83	12.55	101	0.0	89.7	232	2.9
	-1- 4	2798	9.80	14.42	128	0.0	91.2	115	3.5

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TEST B603. PROGENY PERFORMANCE UNDER RHIZOMANIA, IMPERIAL VALLEY, CA, 2002-2003

(cont.)

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	Clean Beets %	NO3-N Mean	Appear Score Mean
F₂(S₁) lines of popn-931 x R36 (cont.)									
2235 -1- 5	1235-1⊗	4307	15.39	14.24	131	0.0	90.8	158	2.9
2235 -2-11	1235-2⊗	3728	15.68	12.01	114	0.0	83.9	259	3.5
-2-12		2585	8.94	14.50	136	0.0	88.0	207	3.7
-2-13		2595	14.18	6.72	142	0.0	67.6	67	2.7
2235 -3-21	1235-3⊗	1115	4.61	12.04	164	0.0	86.5	471	4.4
-3-22		1243	5.01	12.04	150	3.4	87.0	531	4.0
-3-23		959	3.66	13.10	136	0.0	87.7	350	4.9
2235 -4-31	1235-4⊗	2043	10.43	9.86	136	12.1	91.8	610	2.5
Checks									
N112	NR-RZM P912 (A,aa)	5872	20.99	13.85	178	0.0	92.5	328	2.9
N172	NR-RZM N972 (A,aa)	7886	30.73	12.86	148	4.4	92.9	566	2.5
P207/8(Iso)	RZM-PMR-NR P007/8	6766	13.43	14.79	156	0.0	91.1	188	2.5
Y275	RZM-% Y075	7696	26.82	14.46	123	2.4	93.5	349	2.5
Sₙ of line N12 (P912), WB242 resistance									
N212 - 1	N112-#(C)⊗, (=P912⊗)	4859	17.79	13.67	142	0.0	89.6	374	2.8
- 2		5125	18.25	14.09	125	76.0	90.8	278	3.3
- 3		7040	24.13	14.54	123	0.0	92.4	450	2.5
- 4		1636	5.88	13.95	139	0.0	84.6	68	3.2
- 5		0.00	0.00	--.--	145	-.-	--.-	---	3.5
- 6		5629	17.91	15.76	153	1.6	88.2	181	1.9
- 7		6007	22.51	13.38	126	0.0	88.8	402	2.4
- 8		5863	20.22	14.50	128	0.0	91.7	440	2.5
- 9	N112-#(C)⊗, (=P912⊗)	0.00	0.00	--.--	128	-.-	--.-	---	4.7
-10		9150	26.65	17.17	145	0.0	94.1	111	3.2
-11		7145	25.03	14.29	128	0.0	89.9	147	3.0
-12		1592	5.01	15.56	150	0.0	91.9	237	4.5

(cont.)

| Variety | Description | Acre Yield | | Sucrose | Beets/100' | Bolters | Clean Beets | NO3-N | Appear Score |
		Sugar Lbs	Beets Tons	%	No.	%	%	Mean	Mean
S_n of line N12 (P912), WB242 resistance (cont.)									
N212 -13	N112-#(C)⊗, (=P912⊗)	0.00	0.00	--.--	153	-.-	--.-	---	4.0
-14		0.00	0.00	--.--	139	-.-	--.-	---	4.0
-15		0.00	0.00	--.--	92	-.-	--.-	---	4.0
-16		1311	4.47	14.64	109	23.0	78.2	187	2.3
N212 -201	RZM-PMR N112⊗	6042	22.68	13.34	145	0.0	91.0	216	2.2
-202		6597	23.02	14.38	125	0.0	90.7	198	3.2
-203		8145	30.63	13.30	139	0.0	85.7	361	1.2
-204		8172	28.10	14.55	148	0.0	92.9	153	1.3
-205		4906	17.63	13.87	117	0.0	94.7	120	2.7
-206		6673	24.81	13.62	114	0.0	95.5	464	2.7
-207		6851	21.77	15.74	134	0.0	91.8	236	2.9
-208		8747	30.36	14.49	20	0.0	93.0	219	2.0
S_n of line N72, KWS-Bvm resistance									
N272 -1	N172-#(C)⊗	3284	12.92	12.82	117	0.0	89.0	427	3.0
-2		2773	12.45	11.12	139	0.0	83.1	636	2.9
-3		1014	3.64	13.93	103	0.0	88.4	300	4.2
-4		0.00	0.00	--.--	128	-.-	--.-	---	4.7
-221	RZM N172⊗	6755	29.04	11.79	114	7.3	94.7	503	3.2
-222		3374	14.15	11.91	137	0.0	89.9	508	2.9
-223		1071	4.83	11.32	162	0.0	86.5	372	4.2
-224		0.00	0.00	--.--	122	-.-	--.-	---	5.0
-225		2293	8.30	13.86	148	0.0	90.3	393	3.9
-226		7492	28.86	12.98	148	37.8	91.7	446	3.0
-227		3919	18.41	10.78	145	0.0	91.4	115	3.2
-228		4198	16.22	12.98	145	0.0	91.7	102	2.4

Notes: See tests B703, B803-B1103 and from Salinas 6403-1,6503,6603, & 6703.

TEST B903. EVALUATION OF MULTIGERM LINES FOR RESISTANCE TO RHIZOMANIA UNDER SEVERE CONDITIONS, IMPERIAL VALLEY, CA, 2002-2003

96 entries x 4 reps., sequential
1-row plots, 14 ft. long

Planted: September 18, 2002
Not harvested for yield

Variety	Resistance	Description	Stand Count No.	Beets/ 100' No.	Appearance Score 06/02	06/05	Mean
Checks							
Rizor	SES	HH108, 9/3/97	24.8	177	3.5	3.0	3.3
Eagle	Rz	9/16/02	23.0	164	4.0	3.8	3.9
Phoenix	Rz	8/16/01	25.0	179	3.8	3.8	3.8
US H11	--	1999 production	26.3	187	3.8	3.8	3.8
R522(Sp)	Bvm	RZM-8S R322R4, (C51)	24.0	171	2.0	1.8	1.9
B4001R	Rz	9/25/01	23.3	166	3.0	3.3	3.1
B4430R	Rz	8/31/02	23.3	166	3.5	3.5	3.5
Angelina	Rz-Bvm	3/19/02	25.0	179	3.3	3.5	3.4
1927-4H5	Rz-Bvm	C833-5CMS x RZM 9927-4	24.5	175	2.3	2.0	2.1
02-US22/3	--	Inc. 97-US22/3	24.0	171	4.0	3.5	3.8
R039	quant	Inc. R539, (C39R)	22.0	157	3.5	3.5	3.5
Y275	Rz-Bvm	RZM-8S Y075	25.5	182	2.3	2.0	2.1
MM,S^{s}S^s lines							
Y290	Rz	RZM-8S Y090	24.0	171	3.5	3.3	3.4
Y291	Rz-Bvm	RZM Y191	22.3	159	2.8	2.8	2.8
Y292	Rz-Bvm	Inc. Fs(C), C1, Syn 1	23.5	168	2.8	2.5	2.6
99-C31/6	--	Inc. F86-31/6, (C31/6)	21.5	154	4.3	3.5	3.9
R143	Bvm	RZM-ER-8S R943	25.3	180	3.3	3.3	3.3
R276-89	Rz	RZM-8S R076-89	23.5	168	4.3	4.3	4.3
R280-6	Rz	Inc. R080-6	26.8	191	3.8	3.8	3.8
R270-18	Rz	Inc. R070-18	21.8	155	4.0	4.0	4.0
Y269-8	Rz	Inc. Y069-8	24.0	171	3.5	3.3	3.4
Y269-18	Rz	Inc. Y069-18	23.5	168	4.0	3.8	3.9
Y269-39	Rz	Inc. Y069-39	24.5	175	3.0	2.8	2.9
Z210	--	Z010 x Z#(C0, (Polish8S)	23.8	170	4.0	3.8	3.9

TEST B903. EVALUATION OF MULTIGERM LINES FOR RESISTANCE TO RHIZOMANIA UNDER SEVERE CONDITIONS,
IMPERIAL VALLEY, CA, 2002-2003

(cont.)

Variety	Resistance	Description	Stand Count No.	Beets/ 100' No.	Appearance Score 06/02	06/05	Mean
MM,s's lines (cont.)							
Y277	Rz-Bvm	RZM R136-Y175(C)	20.5	146	2.5	2.3	2.4
R221	Rz-Bvm	RZM-% R021	25.8	184	2.3	1.8	2.0
01-C37	--	Inc. U86-37, (C37)	27.8	198	4.8	4.5	4.6
R136	Bvm	RZM-ER-% R936, (C79-8)	22.5	161	3.0	3.0	3.0
Y267-21	Bvm	Inc. Y067-21	20.3	145	3.0	3.0	3.0
Y267-24	Bvm	Inc. Y067-24	22.3	159	2.8	3.5	3.1
Y267-34	Bvm	Inc. Y067-34	24.8	177	3.5	3.3	3.4
Y271-14	Bvm	Inc. Y071-14	22.0	157	3.3	3.3	3.3
R243-14	Bvm	Inc. R043-14	22.8	162	3.3	3.0	3.1
Y275-16	Rz-Bvm	Inc. Y075-16	24.3	173	3.0	2.8	2.9
99-C46/2	--	Inc. U86-46/2, (C46/2)	24.8	177	3.5	3.5	3.5
R278	Rz	RZM R178	17.8	127	3.8	3.5	3.6
R278-2	Rz	Inc. R078-2	23.0	164	3.3	3.5	3.4
R278-7	Rz	Inc. R078-7	25.3	180	3.5	3.8	3.6
R278-14	Rz	Inc. R078-14	24.0	171	3.3	3.8	3.5
R278-16	Rz	Inc. R078-16	22.3	159	3.8	3.8	3.8
R278-27	Rz	Inc. R078-27	21.3	152	4.3	4.3	4.3
R278-4	Rz	Inc. R078-4	22.5	161	4.5	4.8	4.6
R280/2-9	Rz	Inc. R080/2-9	25.0	179	4.3	3.8	4.0
R178	Rz	RZM-ER-% R978	23.3	166	4.0	4.0	4.0
P229-8	Rz-Bvm	Inc. P029-8	20.3	145	4.8	4.5	4.6
P229-20	Rz-Bvm	Inc. P029-20	22.5	161	4.5	3.5	4.0
P230-10	Rz-Bvm	Inc. P030-10	23.0	164	4.3	4.0	4.1
P230-17	Rz-Bvm	Inc. P030-17	21.8	155	4.3	4.0	4.1

TEST B903. EVALUATION OF MULTIGERM LINES FOR RESISTANCE TO RHIZOMANIA UNDER SEVERE CONDITIONS,
IMPERIAL VALLEY, CA, 2002-2003

(cont.)

Variety	Resistance	Description	Stand Count No.	Beets/ 100' No.	Appearance Score		
					06/02	06/05	Mean
Checks							
02-US22/3	--	Inc. 97-US22/3	24.8	177	4.0	4.0	4.0
R522 (Sp)	Bvm	RZM-%S R322R4, (C51)	22.3	159	2.8	2.3	2.5
1927-4H50	Rz-Bvm	C790-15CMS x RZM 9927-4	25.0	179	2.3	2.0	2.1
Angelina	Rz-Bvm	3/19/02	25.5	182	3.3	3.5	3.4
MM,s^{s}s^s lines							
P207/8H50	Rz-Bvm	C790-15CMS x RZM-PMR-NR P007/8	24.8	177	2.8	2.5	2.6
P207/8(Sp)	Rz-Bvm	Inc. P007/8	24.3	173	2.8	2.3	2.5
P207/8H5	Rz-Bvm	C833-5HO x P007/8	26.8	191	2.8	2.5	2.6
P227	Rz-Bvm	PMR-RZM-NB P027-#(C),(CP03)	23.8	170	4.8	4.5	4.6
P128	Rz-Bvm	PMR P028-#(C),(CP04)	23.8	170	2.3	1.8	2.0
P228	Rz-Bvm	PMR-RZM-NB P028-#(C),(CP04)	25.8	184	2.5	2.0	2.3
P229	Rz-Bvm	PMR-RZM-NB P029-#(C),(CP05)	23.0	164	4.0	4.5	4.3
P230	Rz-Bvm	PMR-RZM-NB P030-#(C)	21.5	154	4.0	4.0	4.0
P118-6	Rz-Bvm	Inc. P918-6,(CP08)	20.5	146	2.8	2.3	2.5
P118-6H50	Rz-Bvm	C790-15CMS x P918-6	24.0	171	2.5	2.3	2.4
P207/8(Iso)	Rz-Bvm	RZM-PMR-NR P007/8,(CP07)	25.3	180	2.0	1.8	1.9
R275	Rz-Bvm	RZM-% Y075	25.8	184	2.3	1.8	2.0
02-WB97	Bvm	Inc. WB97, SB x WB97	20.0	143	3.3	3.0	3.1
02-WB242	Bvm	Inc. WB242, SB x WB242	23.8	170	1.8	1.5	1.6
MM,s^f,Aa populations & lines							
0747	--	Inc. 7747(A,aa)	22.0	157	4.5	4.3	4.4
2931	Rz	RZM-% 0931(A,aa)	23.0	164	4.3	3.5	3.9
N112	Rz-Bvm	NR-RZM P912(A,aa)	23.8	170	2.3	1.5	1.9
N172	Rz-Bvm	NR-RZM N972(A,aa0	24.5	175	2.0	2.0	2.0

(cont.)

Variety	Resistance	Description	Stand Count No.	Beets/ 100' No.	Appearance Score 06/02	06/05	Mean
MM,S^f,Aa populations & lines (cont.)							
0926	*Rz-Bvm*	RZM-ER-% 8926(Sp)	25.5	182	2.5	2.8	2.6
2921	*Rz-Bvm*	RZM-% 0921	24.3	173	3.0	3.0	3.0
2941	*Rz*	RZM-% 0941(A,aa)	24.8	177	3.8	3.5	3.6
Z225	*Rz*	RZM-% Z025	23.0	164	3.8	3.5	3.6
CR211	*Rz*	RZM-% CR011	23.8	170	4.3	3.8	4.0
2933	*Rz*	RZM-% 9933	21.3	152	4.0	3.8	3.9
2942	*Rz*	RZM-% 0942	22.8	162	3.8	3.8	3.8
CR214	*Rz*	Inc. 1241,2,3-#(C)	24.8	177	3.8	3.8	3.8
2927-4	*Rz-Bvm*	RZM 1927-4,(C927-4)	25.3	180	2.3	2.0	2.1
Z225-9	*Rz*	RZM Z025-9,(CZ225-9)	22.8	162	4.8	4.8	4.8
MM,NR lines & hybrids							
N224	*Rz-Bp*	RZM-NR N124	21.5	154	3.0	3.0	3.0
N224H98	*Rz-Bp*	N165-9H50(g) x RZM-NR N124	21.5	154	3.0	2.5	2.8
N224(C)	*Rz-Bp*	Inc. N124-#(C)(g)	22.5	161	3.5	3.5	3.5
N224(C)H94	*Rz-Bp*	N165-9HO(g) x N124-#(C)(g)	21.5	154	2.8	2.5	2.6
MM,S^f,Aa lines							
2930-19	*Rz*	RZM 1930-19aa x A	23.3	166	4.8	4.8	4.8
2930-35	*Rz*	RZM 1930-35aa x A	25.0	179	4.3	4.5	4.4
2929-45	*Rz*	9929-45aa x A	24.0	171	4.8	4.8	4.8
2936-10	*Rz*	RZM 0936-10aa x A	21.0	150	4.5	4.5	4.5
2936-16	*Rz*	0936-16aa x A	24.0	171	4.0	4.0	4.0
2931-3	*Rz*	Inc. 0931-3	21.5	154	4.0	4.0	4.0
2931-20	*Rz*	Inc. 0931-20	23.5	168	5.0	5.0	5.0
2941-20	*Rz*	Inc. 0941-20	19.0	136	5.0	5.0	5.0

TEST B903. EVALUATION OF MULTIGERM LINES FOR RESISTANCE TO RHIZOMANIA UNDER SEVERE CONDITIONS,
IMPERIAL VALLEY, CA, 2002-2003

(cont.)

Variety	Resistance	Description	Stand Count No.	Beets/ 100' No.	Appearance Score 06/02	06/05	Mean
MM,S^f,Aa lines (cont.)							
2927-4	Rz-Bvm	RZM 1927-4, (C927-4)	24.3	173	2.0	2.0	2.0
2933-14	Rz	Inc. 0933-14	24.8	177	4.5	4.5	4.5
2933-17	Rz	Inc. 0933-17	23.0	164	4.8	4.5	4.6
2933-7	Rz	Inc. 0933-7	23.3	166	4.3	4.3	4.3
Mean			23.4	167.3	3.5	3.3	3.4
LSD (.05)			3.7	26.3	0.7	0.8	0.7
C.V. (%)			11.3	11.3	14.9	16.9	13.8
F value			1.7**	1.7**	10.3**	10.2**	13.4**

Notes: See tests B603-B1103. Tests B903-B1103 were in a field plot area with severe rhizomania and soil-
borne problems. This area had been in sugarbeet trials every other year since about 1990. Because of the
severity of disease, plots were scored only for survival/appearance on a scale of 1 to 5, where 1 = what
normal appearance would like be for time of year and 5 = very poor or dead.

Source of resistance: Rz = Holly gene; Bvm = Beta vulgaris subsp. maritima, including C51 (C50, R22),
WB97, and/or WB242; Q = quantitative resistance; Bp = B.procumbens for sugarbeet cyst nematode (SBCN)
resistance.

A133

Planted: June 9-10, 2003
Inoculated: July 17-18, 2003 at 1.15 leaf hoppers/plant

232 entries* x 3 reps, 2-row plots, 13 ft. long, sequential
40 entries* x 3 reps, 1-row plots, 13 ft. long, sequential

Variety	Description		BSDF[1] 1st Rating 8/18/03	BSDF[2] 2nd Rating 09/03	BSDF[3] 2nd Rating 9/02/03
Hybrids					
US H11	resist ck, 10/14/02		3.7	3.3	4.7
WS-PM21	resist ck, 4/03		3.3	4.0	4.3
Eagle	9/16/02		4.7	5.7	6.3
Phoenix	9/16/02		4.7	5.7	6.7
Beta 4776R	2/12/03		4.7	5.7	7.0
Beta 4430R	2/12/03		4.3	5.3	6.7
Monohikari	susc ck, 1/21/03		4.7	5.7	6.3
Beta 4001R	2/12/03		4.0	5.0	6.0
HH141	8/16/01		4.0	5.3	6.0
HM-E17	3/21/02, susc ck		4.3	5.3	6.3
Angelina	3/10/03		4.3	5.0	6.0
US H11	resist ck, 10/14/02		3.3	3.3	4.0
Hybrids with C833-5CMS tester					
R278H5	C833-5CMS	x RZM R178 (C78)	3.7	4.3	4.3
Y190H5		x Y090	4.0	4.7	4.7
Y291H5		x RZM Y191	4.3	4.0	4.7
Y175H5		x Y75 (C)	4.0	4.0	4.3
Y277H5		x RZM R136-Y175	4.0	4.0	4.3
P207/8H5		x P007/8 (CP07)	3.7	4.0	4.3
Z210H5		x PX %S Polish(C)	4.0	4.7	5.0
Monohikari	Susc. ck., 1/21/03		5.3	7.0	6.7
1931H5	C833-5CMS	x RZM 0931(C)	4.3	4.7	5.0
1941H5		x RZM 0941(C)	4.0	4.7	5.0
Z125H5		x RZM Z025(C)	4.3	5.0	5.0
2943H5		x PX %S MM,S^f(C)	4.3	5.0	5.0
1927-4H5		x RZM 9927-4 (C927-4)	4.3	5.0	5.0
1929-4H5		x RZM 9929-4	4.3	5.0	5.0
1924-2H5		x RZM 9924-2	4.7	4.7	5.0
1929-62H5		x RZM 9929-62 (C929-62)	4.7	5.0	5.0
R278-4H5	C833-5CMS	x R078-4	4.0	4.0	4.7
R280/2-9H5		x R080/2-9	4.3	5.3	5.0
Z225-9H5		x RZM Z025-9(CZ25-9)	4.0	4.7	5.0
2929-45H5		x RZM 9929-45	4.3	5.0	5.0
2930-19H5	C833-5CMS	x RZM 1930-19 (C930-19)	4.0	4.3	5.0

Variety	Description		BSDF[1] 1st Rating 8/18/03	BSDF[2] 2nd Rating 09/03	BSDF[3] 2nd Rating 9/02/03
Hybrids with C833-5CMS tester (cont.)					
2930-35H5	x RZM 1930-35 (C930-35)				
			3.7	4.0	4.0
2936-10H5	x RZM 0936-10		4.3	4.7	5.0
2936-16H5	x 0936-16		4.3	5.0	5.0
Topcross hybrids with C78/3					
Monohikari	susc. ck., 1/21/03		6.0	8.0	7.3
WS-PM21	resist ck, 4/03		3.7	4.3	4.3
US H11	resist ck, 10/14/02		3.7	4.0	4.3
R278H50	C790-15CMS x R178 (C78/3)		3.7	4.7	4.7
R278H5	C833-5CMS	x R178	4.0	5.0	5.0
R278H2	C831-3HO	x R178	4.0	4.3	4.7
R278H27	C831-4HO	x R178	3.3	3.7	4.3
R278H82	C833-5H2	x R178	4.3	4.7	4.3
R278H83	C833-5H27	x R178	4.0	4.0	4.7
R278H84	C833-5H45	x R178	3.3	4.0	4.3
R278H45	C867-1HO	x R178	3.3	4.0	4.3
R278H75	1835-11H5	x R178	3.7	4.0	4.7
R278H76	1835-26H5	x R178	4.0	4.0	4.7
R278H67	0837-6H5	x R178	4.0	4.3	4.3
R278H77	1833-5-8HO	x R178	4.0	4.7	4.7
R278H78	1833-5-11HO	x R178	4.0	4.7	5.0
R278H28	0831-4-7HO	x R178	4.0	4.7	5.0
R278H29	0831-4-10HO	x R178	4.0	5.0	5.0
R278H56	1836HO	x R178	4.3	4.7	5.0
R278H42	C842HO	x R178	4.0	4.7	4.7
R278H55	1835HO	x R178	3.7	3.7	4.7
R278H70	C869HO	x R178	3.7	3.7	4.7
R278H73	01-FC123H5	x R178	3.7	3.3	4.3
R278H74	01-FC1014H5	x R178	3.7	4.3	4.3
R278H95	N165-#(g)aa	x R178	4.0	4.3	4.7
R278H96	N165HO	x R178	4.0	4.3	4.7
R278H97	N167HO	x R178	4.0	3.7	4.3
R278H31	RZM 1931(Iso)aa	x R178	3.7	4.7	4.0
R278H41	RZM 1941aa	x R178	3.7	4.0	4.0
R278H23	CZ25-9aa	x R178	3.7	4.7	4.3
R278H25	Z125aa	x R178	4.0	4.7	4.7
R278H40	C930-35aa	x R178	4.0	4.0	4.7
Hybrids with C790-15CMS x tester					
US H11	resistant ck., 10/14/02		3.7	3.7	4.0
Monohikari	susceptible ck., 1/21/03		5.3	7.3	7.3

Variety	Description	BSDF[1] 1st Rating 8/18/03	BSDF[2] 2nd Rating 09/03	BSDF[3] 2nd Rating 9/02/03
Hybrids with C790-15CMS x tester (cont.)				
Y277H50	C790-15CMS x RZM R136-Y175	4.3	5.0	5.3
R278H50	x R178 (C78/3)	3.7	4.3	4.7
Z210H50	C790-15CMS x %S(C)	3.3	5.0	5.0
P207/8H50(Sp)	x P007/8 (CP07)	3.7	4.0	4.3
Y291H50	x RZM Y191	4.0	4.3	4.7
R278-4H50	x R078-4	3.7	3.7	4.0
R280/2-9H50	x R080/2-9	4.0	5.0	4.7
2936-10H50	x RZM 0936-10	4.0	4.3	4.3
2936-16H50	x RZM 0936-16	4.0	3.7	4.3
2943H50	x MM,S^f,Aa,%S(C)	3.7	4.0	4.7
2930-35H50	x RZM 1930-35(C930-35)	3.3	3.0	4.3
2930-19H50	x RZM 1930-19(C930-19)	3.7	3.7	4.7
2929-45H50	x RZM 9929-45	3.7	4.7	4.7
Y290-H50	x RZM-% Y090	4.0	4.7	4.7
Y275H50	x RZM-% Y075	4.3	4.7	5.0
R276-89H50	x RZM-% R076-89	4.3	5.7	5.3
P207/8H50(Iso)	x RZM-PMR-NR P007/8 (CP07)			
		4.3	4.7	5.0
Nematode resistant hybrids				
N224H98	N165-9H50(g) x RZM-NR N124	4.3	5.3	5.3
N224(C)H94	N165-9HO(g) x N124-#(C)(g)	3.7	5.0	5.0
Topcross hybrids with Y91				
Y291H73	01-FC123H5 x RZM Y191	4.3	4.3	5.0
Y291H74	01-FC1014H5 x RZM Y191	4.3	4.7	4.7
Y291H31	RZM 1931aa x RZM Y191	4.3	4.7	5.0
Y291H41	RZM 1941aa x RZM Y191	4.0	4.7	5.0
Y291H11	RZM CR111aa x RZM Y191	4.0	4.3	5.0
Y291H23	CZ25-9aa x RZM Y191	4.0	4.3	4.7
Y291H25	RZM Z125aa x RZM Y191	3.7	4.3	4.3
Multigerm, S^{s}S^s lines				
US H11	resist ck, 10/14/02	3.0	3.3	4.3
01-C37	Inc. U86-37, resist. check	3.0	3.0	4.0
01-US75	Inc. 00-US75	3.0	3.3	4.0
02-US22/3	Inc. 97-US22/3	3.0	3.7	4.0
Z210	Inc. Polish %S(C)	4.0	5.7	6.3
01-EL0204	RZM OO-EL0204 (SR x Rz)	4.0	6.0	6.0
01-FC1030	FC1030(C)aa x A	4.3	5.3	5.3
R221	RZM-%S R021, (C26,C27)	4.3	5.3	5.3

Variety	Description	BSDF[1] 1st Rating 8/18/03	BSDF[2] 2nd Rating 09/03	BSDF[3] 2nd Rating 9/02/03
Multigerm, S^{s}S^s lines (cont.)				
99-C46/2	Inc. U86-C46/2	4.0	4.0	5.0
R278	RZM R178 (C78/3)	3.7	4.0	4.7
99-C31/6	Inc. F86-31/6	4.0	5.0	5.0
R276-89	RZM-% R076-89	4.0	4.3	5.0
Y169	RZM-ER-% Y969, (C69/2)	4.0	4.3	5.0
Y290	RZM-% Y090	4.3	4.3	4.7
Y291	Inc. Y191	4.0	4.3	4.7
Y292	Inc. FS(C), Cycle 1, Syn 1	4.3	5.0	5.0
R180	RZM-ER-% R980, (C80/2)	4.0	5.3	5.3
Y167	RZM-ER-% Y967, (C67/2)	4.3	5.0	5.7
Y275	RZM-% Y075	4.3	5.0	5.3
Y277	RZM R136-Y175	4.7	4.7	5.0
Y171	RZM-ER-% Y971	3.7	4.3	5.0
R136	RZM-ER-% R936 (C79-8)	3.7	4.0	4.0
R824	RZM R724 (C79-2,-3; WB41,42)	3.3	4.0	4.3
R724	RZM R824 (C79-2;WB41)	3.7	4.3	4.7
R725	RZM R425,R525 (C79-3;WB42)	4.0	5.0	5.0
R637	RZM R537,R550 (C79-9;WB151)	3.7	4.0	4.3
P207/8(Iso)	RZM-PMR-NR P007/8 (CP07)	3.7	4.3	4.7
P207/8(Sp)	Inc. P007/8	3.3	4.3	4.7
P227	PMR-RZM-NB P027-#(C),(CP03)	3.3	3.7	4.0
P228	PMR-RZM-NB P028-#(C),(CP04)	3.3	4.0	4.3
P229	PMR-RZM-NB P029-#(C),(CP05)	4.0	4.7	4.7
P230	PMR-RZM-NB P030-#(C),(CP06)	4.3	5.3	5.0
P229-8	Inc. P029-8	5.0	5.7	5.7
P229-20	Inc. P029-20	4.0	4.7	5.0
P230-10	Inc. P030-10	4.7	4.7	4.7
P230-17	Inc. P030-17	4.3	4.7	4.7
R278-4	Inc. R078-4	3.3	4.3	4.3
R278-2	Inc. R078-2	4.3	5.0	5.3
R278-7	Inc. R078-7	3.7	4.3	5.0
R278-14	Inc. R078-14	4.0	5.0	5.0
R278-16	Inc. R078-16	4.3	5.3	5.3
R278-27	Inc. R078-27	4.0	4.0	5.0
R280/2-9	Inc. R080/2-9	4.3	5.7	5.7
R280-6	Inc. R080-6	4.3	4.7	5.0
R270-18	Inc. R070-18	3.7	4.3	4.7

(cont.)

Variety	Description	BSDF[1] 1st Rating 8/18/03	BSDF[2] 2nd Rating 09/03	BSDF[3] 2nd Rating 9/02/03
Multigerm, S^sS^s lines (cont.)				
Y269-8	Inc. Y069-8	3.7	4.0	4.3
Y269-18	Inc. Y069-18	3.0	4.0	4.0
Y269-39	Inc. Y069-39	3.7	4.7	4.7
R243-14	Inc. R043-14	4.3	5.3	5.0
Y267-21	Inc. Y067-21	4.3	4.7	4.7
Y267-24	Inc. Y067-24	4.3	4.7	4.7
Y267-34	Inc. Y067-34	4.3	4.7	5.0
Y271-14	Inc. Y071-14	4.0	4.7	5.0
Y275-16	Inc. Y075-16	4.0	5.0	5.0
R178-6	Inc. R978-6	4.0	4.7	4.3
R180-21	Inc. R980-21	3.7	5.7	5.3
Y168-8	Inc. Y968-8	4.3	5.3	5.3
Y181-22	Inc. Y981-22, (C81-22)	3.7	5.0	5.0
R176-89-5NB-4	Inc. R976-89-5NB-4	4.7	6.0	5.3
Y172-5	Inc. Y972-5	4.3	5.3	5.0
Multigerm, S^f,Aa populations & lines				
US H11	resist ck, 10/14/02	4.0	3.7	4.0
0747	Inc. 7747 (A,aa)	3.3	4.0	4.0
2931	RZM-% 0931 (A,aa)	4.0	5.0	5.0
2941	RZM-% 0941 (A,aa)	4.0	4.7	4.7
Z225	RZM-% CZ25 (A,aa)	4.7	6.0	5.7
CR211	RZM-% CR011 (A,aa)	4.7	5.3	5.0
2933	RZM-% 9933 (A,aa)	5.0	5.3	5.3
2942	RZM-% 0942 (A,aa)	4.3	4.7	4.7
2921	RZM-% 0921	4.0	5.0	5.0
2943-9	CZ25-9aa x (C)	4.3	5.3	5.0
2943-35	C930-35aa x (C)	4.0	5.0	4.7
2943-19	C930-19aa x (C)	4.3	4.7	5.0
CR214	Inc. 1241,2,3-#(C)	5.0	6.0	5.7
N224	RZM-NR N124 (A,aa)	4.7	5.3	5.3
N112	NR-RZM P912 (A,aa)	4.3	5.0	5.0
N172	NR-RZM N972 (A,aa)	4.3	6.0	5.3
Z225-9	RZM Z025-9 (CZ25-9)	4.3	6.0	6.0
2930-35	RZM 1930-35aa x A (C930-35)	4.0	4.7	5.0
2930-19	RZM 1930-19aa x A (C930-19)	4.3	4.7	5.0
2927-4	RZM 1927-4 (A,aa) (C927-4)	4.0	5.3	5.0
1924-2	RZM 9924-2aa x A	4.0	4.7	5.3
1929-4	RZM 9929-4aa x A	4.0	6.3	6.0
1931-56	Inc. 9931-56 (A,aa)	4.0	5.3	5.7
Z131-14	Inc. Z931-14 (A,aa)	4.7	6.3	5.7

Variety	Description	BSDF[1] 1st Rating 8/18/03	BSDF[2] 2nd Rating 09/03	BSDF[3] 2nd Rating 9/02/03
Multigerm, S[f],Aa populations & lines (cont.)				
2929-45	9929-45aa x A	5.3	5.3	6.0
2936-10	RZM 0936-10aa x A	4.7	5.3	5.3
2936-16	0936-16aa x A	4.0	5.0	5.0
2931-3	Inc. 0931-3 (A,aa)	4.3	4.7	5.0
2931-20	Inc. 0931-20 (A,aa)	4.3	5.3	5.0
2941-20	Inc. 0941-20 (A,aa)	6.0	8.0	7.3
2933-7	Inc. 0933-7 (A,aa)	4.7	5.3	5.3
2933-14	Inc. 0933-14 (A,aa)	4.3	5.3	5.0
2933-17	Inc. 0933-17 (A,aa)	4.0	4.3	4.3
CR210-2	Inc. CR910-2 (Sp) (A,aa)	4.3	5.3	5.7
CR211-7	Inc. CR911-7 (Sp) (A,aa)	4.7	5.3	5.7
CR110-14-2	Inc. CR910-14-2 (A,aa)	4.7	5.0	5.7
CR110-5	Inc. CR910-5 (A,aa)	4.7	6.3	6.0
CR112-5	Inc. CR912-5 (A,aa)	5.0	6.7	6.3
US H11	resist ck, 10/14/02	4.0	3.3	4.7
Monohikari	susc ck, 1/21/03	5.0	7.0	6.7
Monogerm populations & lines				
01-FC123	FC123(C)mmaa x A, (FC301)	4.3	4.3	4.7
01-FC1014	00-FC1014mmaa x A, (FC201)	3.7	5.0	5.0
02-FC124	RZM 01-123H7		4.0	4.7
4.7				
02-FC1015	RZM 01-FC1014H7	4.0	5.3	4.7
1869(C)	RZM 0869-#(C)mmaa x A (C869)	4.0	4.7	4.7
1869HO	0869HO x " " (C869CMS)	4.0	5.0	5.0
2790H7	RZM 1833-5aa x 0790	4.3	4.7	4.7
2790	0790mmaa x A (C790)	3.7	4.3	4.3
2835	RZM,T-O 1835-#(C)mmaa x A	3.3	4.0	4.0
2836	RZM,T-O 1836-#(C)mmaa x A	3.7	4.3	4.3
2837	RZM,T-O 1836H7-#(C)mmaa x A	3.7	4.7	4.7
2842	RZM 1842mmaa x A, (C842)	3.7	4.0	4.3
2848	RZM,T-O 1848-#(C)mmaa x A	3.7	4.3	4.3
2843	RZM-% 0841H7 (A,aa)	3.7	4.0	4.0
2846	RZM-% 0841H69 (A,aa)	3.7	4.0	4.0
02-C790-15CMS	99-C790-68CMS x 00-C790-15	3.7	4.3	4.0
02-C790-15	Inc. 00-C790-15	3.3	4.7	4.0
99-C790-68	Inc. U88-C790-68	4.3	5.3	4.7
2833-5(Sp)	RZM,T-O 1833-5#(C)mmaa x A(C833-5)	4.0	5.0	5.0
2833-5NB(Iso)	NB-RZM-% 0833-5(A,aa)	4.0	5.0	5.0

Variety		Description	BSDF[1] 1st Rating 8/18/03	BSDF[2] 2nd Rating 09/03	BSDF[3] 2nd Rating 9/02/03
Monogerm populations & lines (cont.)					
0546		Inc. 97-C546	4.0	4.7	4.3
0562		Inc. 97-C562	3.3	4.0	4.0
2869-15		Inc. 0869-15 (A,aa)	5.3	6.3	5.3
2840-9		Inc. 0840-9 (A,aa)	3.7	4.7	5.0
2835-8		Inc. 9835-8 (A,aa)	4.0	5.0	5.0
2835-10		Inc. 9835-10 (A,aa)	3.7	4.3	4.7
2835-24		Inc. 9835-24 (A,aa)	3.0	4.0	4.3
2836-13		Inc. 9836-13 (A,aa)	4.3	5.3	5.7
2810-17		Inc. 9810-17 (A,aa)	4.0	4.7	5.3
2810-19		Inc. 9810-19 (A,aa)	3.7	4.7	4.7
2848-1		Inc. 9848-1 (A,aa)	3.0	4.3	4.3
0762-17		Inc. 6762-17 (C762-17)	3.0	3.7	4.0
Monogerm, nematode resistant lines					
N265-31HOM		N165-9HO(g) x N165-31(g)	4.7	6.0	5.3
N265-9HO		N165-9HO(g) x RZM N165-9(g)	3.7	6.0	5.3
N265		RZM-NR N165	4.3	5.3	5.0
N267		RZM-NR N167	4.0	4.3	4.7
S₁ progeny from Multigerm lines					
N212	-201	RZM-PMR N112⊗	4.0	4.7	5.0
	-202		4.0	5.0	5.0
	-203		4.0	5.0	5.0
	-204		4.3	4.3	5.0
N272	-221	RZM N172⊗	4.3	6.0	6.3
	-222		4.3	5.7	5.7
	-223		4.3	7.0	6.3
	-224		4.7	5.0	5.7
2953	-201	RZM Y190H31⊗	3.7	3.7	4.7
	-202		3.7	4.3	4.7
	-203		4.0	4.7	5.0
	-204		4.3	5.0	5.3
2953	-205	RZM Y190H31⊗	4.0	6.0	6.0
	-206		4.3	5.3	5.3
	-207		4.3	5.7	5.7
	-208		4.7	5.7	5.7
S₂ progeny from C37 x 9719Bm					
2221	-2-1	1221-2⊗	4.7	5.3	5.0
	-2-2		4.0	4.7	5.0
221	-3-1	1221-3⊗	3.7	4.0	4.7
	-3-2		3.7	4.0	4.7

(cont.)

Variety		Description	BSDF[1] 1st Rating 8/18/03	BSDF[2] 2nd Rating 09/03	BSDF[3] 2nd Rating 9/02/03
S$_2$ progeny from C37 x 9719Bm (cont.)					
2221	-4-1	1221-4⊗	3.7	4.0	4.7
	-4-2		4.0	4.0	4.3
2221	-5-1	1221-5⊗	4.3	4.3	4.7
	-5-2		3.7	4.7	4.7
S$_2$ progeny from C78 x 9719Bm					
2222	-1-1	1222-1⊗	4.7	5.0	5.0
	-1-2		4.7	5.3	5.3
2222	-3-1	1222-3⊗	4.0	5.0	5.0
	-3-2		4.0	5.3	5.7
2222	-7-1	1222-7⊗	4.0	4.7	5.0
	-7-2		3.7	4.3	5.0
S$_2$ progeny from popn-931aa x 9719Bm					
2223	-1-1	1223-1⊗	3.0	3.3	4.3
	-1-2		4.0	4.3	5.0
2223	-3-1	1223-3⊗	4.0	3.7	5.0
	-3-2		3.7	3.7	4.3
2223	-4-1	1223-4⊗	5.0	6.7	6.0
	-4-2		5.0	5.3	5.3
Checks for S$_2$ progeny					
2930-19		RZM 1930-19 (C930-19)	4.3	4.0	4.7
R278		RZM R178 (C78)	3.7	4.0	4.7
9719		Inc. 6719 (C719Bm)	4.0	4.3	4.3
01-C37		Inc. 86-C37	3.0	3.3	4.0

Notes: Scored on a scale of 0-9 where 9 is dead. P = phoma & E = Erwinia rated
in rep 1 only.

[1]Rated 8/18/03 by Dr. Linda Hanson.

[2]Rated by Dr. Lee Panella.

[3]Rated 9/2/03 by Terry Brown.

Acknowledge the assistance of Terry Brown, Tom Schwartz, Linda Hanson, Lee
Panella, John Gallian, and the BSDF BCT Nursery Committee.

TEST 8403. EVALUATION OF LINES UNDER RHIZOMANIA AND CERCOSPORA LEAF SPOT, SALINAS, CA, 2003

48 entries x 8 reps., sequential
1-row plots, 11 ft. long

Planted: May 1, 2003
Harvested: November 17, 2003
Inoculated C.b.: August 22, 2003

| Variety | Description | Sugar Yield | | | Stand Count | Harv Count | Root Rot | RJAP | Powdery Mildew | Rhizomania Resistance | | CLS |
		Sugar Lbs	Beets Tons	Sucrose %	No.	No.	%	%	Score	DI	%R(0-4)	Score
Line checks												
Roberta	3/25/03, susc. ck.	1001	3.70	12.02	22	14	1.9	75.3	1.0	5.65	3.6	3.6
01-EL0204	RZM oo-EL0204	7129	22.30	16.15	22	21	0.0	84.4	3.6	3.56	83.5	2.4
R278	RZM R178, C78/3	5792	16.30	17.67	20	19	0.0	84.2	3.3	4.07	64.8	2.0
Y290	RZM-% Y090	7308	20.21	18.09	22	20	0.0	84.9	3.3	4.10	59.2	1.9
Y275	RZM-% Y075	8874	25.67	17.30	22	21	0.5	83.4	2.4	3.80	72.0	1.3
R221	RZM-% R021, C26/27	8209	24.82	16.60	22	21	0.0	83.0	2.8	3.47	86.2	1.5
01-FC1030	RZM FC1030aa x A	5172	15.40	16.92	21	17	0.5	83.5	3.8	4.86	31.1	1.8
Z210	PX %S Polish(C)	2409	7.85	15.32	20	15	4.3	72.9	3.3	5.74	5.9	3.5
Lines												
2931	RZM-% 0931 (A,aa)	6286	18.30	17.32	22	20	2.7	81.4	1.6	3.79	75.8	2.0
CR214	Inc. 1241-#(C)	5255	16.12	16.34	20	18	0.0	82.5	1.8	4.69	39.2	2.1
2933	RZM-% 9933 (A,aa)	6810	19.71	17.33	22	20	0.0	85.0	2.1	3.86	69.9	1.6
2933-7	Inc. 0933-7 (A,aa)	6547	18.95	17.33	22	20	0.5	83.5	2.8	4.20	51.3	1.0
2933-14	Inc. 0933-14 (A,aa)	5201	14.22	18.27	22	21	0.0	84.8	0.5	3.80	75.2	1.6
2933-17	Inc. 0933-17 (A,aa)	4379	12.57	17.44	22	18	0.0	83.9	1.4	4.10	61.2	1.5
CR211	RZM-% CR011 (A,aa)	7640	22.23	17.25	21	20	0.0	83.6	3.0	3.96	63.5	1.0
CR111	RZM CR011aa x A	7100	20.95	16.98	21	20	0.0	85.5	3.8	3.86	66.9	1.5
CR011	RZM CR910,911,912aa x A	6764	20.58	16.48	21	21	0.0	82.9	3.8	3.71	74.3	1.3
CR910	RZM R710,R709-9,R710-10,R710-14	6678	20.00	16.74	22	22	0.0	85.0	4.3	3.77	73.2	1.1
CR009-1	RZM CR909-1aa x A, (CR09-1)	5165	15.05	17.14	21	20	1.2	79.7	1.9	3.38	94.2	1.1
CR211-7	Inc. CR911-7 (Sp)	6268	18.52	16.95	20	19	0.0	83.4	3.6	3.91	68.5	1.5

(cont.)

Variety	Description	Sugar Yield Sugar Lbs	Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	Root Rot %	RJAP %	Powdery Mildew Score	Rhizomania Resistance DI	%R(0-4)	CLS Score
Lines (cont.)												
CR210-2	Inc. CR910-2 (sp)	7539	22.23	17.00	19	18	0.7	83.9	4.8	3.59	84.8	1.4
CR112-5	Inc. CR812-5, (Inc. S$_1$ line)	4987	15.38	16.33	23	20	1.7	84.3	5.8	3.69	79.8	1.9
CR110-5	Inc. CR910-5, (Inc. S$_1$ line)	4538	13.67	16.14	20	18	0.6	78.6	3.1	4.25	48.8	1.1
CR110-14-2	Inc. CR910-14-2 (Inc. S$_2$ line)	2009	6.62	14.52	22	20	0.0	71.0	2.1	4.79	19.2	1.3
20021028	FC709-2 x 9933	5923	17.11	17.29	24	21	0.7	84.5	1.8	4.11	60.6	1.6
20021037	(FC·LSR x EL·LSR) x CR11	6121	18.46	16.63	23	21	0.0	83.0	4.1	4.30	54.4	1.9
20021038	(FC·LSR x EL·LSR) x CR10	5943	17.52	17.00	22	21	0.5	84.8	3.9	3.94	66.9	1.5
Monogerm lines and populations												
2842	RZM 1842mmaa x A, C842	5913	18.35	16.08	22	21	0.0	81.5	4.9	3.76	73.2	2.3
01-FC123	RZM FC123mmaa x A,FC301	4164	12.35	16.96	20	19	0.0	83.9	4.4	4.68	35.0	2.6
20021022	FC's FC123mm, (4/16/03)	5891	17.98	16.41	22	19	0.6	86.4	3.6	4.13	56.9	2.5
20021023	FC's FC123M, (4/16/03)	3117	9.27	16.85	22	18	0.0	80.5	3.3	4.48	42.9	2.0
01-FC123H5	C833-5HO x RZM FC123	5418	15.82	17.19	20	19	0.6	83.2	3.6	4.05	62.2	1.6
02-FC124	RZM 01-FC123H7	5007	14.08	17.88	22	20	1.0	82.8	2.8	3.98	65.4	1.4
02-FC124HO	RZM 01-FC123H5 x RZM 01-FC123H7	7060	19.66	18.02	22	22	0.0	82.9	3.1	3.81	73.2	1.3
01-FC1014	RZM FC1014mmaa x A,FC201	5056	14.31	17.70	19	18	1.2	83.2	3.8	4.68	35.6	1.6
01-FC1014H5	0833-5HO x RZM FC1014	7042	19.25	18.26	20	20	0.0	82.4	3.0	3.55	79.9	1.6

TEST 8403. EVALUATION OF LINES UNDER RHIZOMANIA AND CERCOSPORA LEAF SPOT, SALINAS, CA, 2003

Variety	Description	Sugar Yield Sugar Lbs	Beets Tons	Sucrose %	Stand Count No.	Harv Count No.	Root Rot %	RJAP %	Powdery Mildew Score	Rhizomania Resistance DI	%R(0-4)	CLS Score
Monogerm lines and populations (cont.)												
02-FC1015	RZM 01-FC1014H7	6168	17.39	17.74	23	20	0.0	83.5	2.6	3.88	67.1	1.6
02-FC1015HO	RZM 01-FC1014H5 x RZM 01-FC1014H7											
		7005	19.44	18.04	21	20	0.5	83.5	3.3	3.73	76.3	1.6
Hybrids												
R278H73	01-FC123H5 x RZM R178, (C78/3)											
		8429	23.45	17.98	22	21	0.0	85.1	2.9	3.55	81.9	1.9
R278H74	01-FC1014H5 x RZM R178, (C78/3)											
		7461	20.47	18.24	21	20	0.0	83.4	3.1	3.82	70.4	2.1
R278H5	C833-5HO x RZM R178, (C78/3)											
		8239	22.45	18.33	20	19	0.0	84.7	3.3	3.50	81.8	1.6
2933H50	C790-15CMSxRZM-% 9933	6734	20.10	16.79	22	21	0.0	85.5	3.5	4.29	54.1	2.4
Beta 4430R	2/12/03	8817	25.57	17.25	24	24	0.0	87.2	1.5	3.20	90.4	3.9
Monohikari	lot 8033,rec'd 2/22/02	1649	6.25	12.95	20	13	4.4	76.0	3.6	6.21	0.7	2.4
ACH555	CLSR check, 3/8/02	1505	4.88	15.18	23	17	1.6	78.5	2.6	6.22	2.3	1.5
HM-E17	rec'd 3/21/02	1544	5.67	12.98	24	17	3.8	74.6	3.4	6.26	1.1	2.1
Monodoro	rec'd 3/21/02	4128	12.80	16.25	23	20	2.4	85.3	4.1	5.78	5.1	2.3
Dorotea	rec'd 3/21/02	7622	21.99	17.40	19	18	0.0	86.1	2.8	4.70	32.2	2.3
Mean		5729.5	16.79	16.77	21.4	19.3	0.7	82.6	3.1	4.23	56.7	1.8
LSD (.05)		937.9	2.72	1.07	2.3	2.5	2.9	4.2	0.9	0.33	13.8	0.8
C.V. (%)		16.6	16.45	6.47	10.7	13.1	438.7	5.2	30.4	7.87	24.7	43.1
F value		35.0**	31.67**	12.43**	2.6**	4.9**	1.2NS	5.4**	9.6**	42.85**	28.0**	5.1**

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TEST 8403. EVALUATION OF LINES UNDER RHIZOMANIA AND CERCOSPORA LEAF SPOT, SALINAS, CA, 2003

(cont.)

| Variety | Description | Sugar Yield | | Sucrose | Stand Count | Harv Count | Root Rot | RJAP | Powdery Mildew | Rhizomania Resistance | | CLS |
		Sugar Lbs	Beets Tons	%	No.	No.	%	%	Score	DI	%R(0-4)	Score

NOTES: Rhizomania was very severe and many plants that would normally be scored as 4's appeared to become 5's and thus were considered susceptible. Relatively, this should be a good rhizomania test.

Cercospora beticola was inoculated three times on a two week schedule starting August 22, 2003. Leafspot infection remained very mild and probably had no impact on performance. A single rating on the 0 to 9 scale was done on 11/14/03.

Descriptions: 01-EL0204 was releaed as EL0204 for combined smooth root, rhizomania, and performance by J.M. McGrath et al. 01-FC1030 combines resistance to rhizomania and Rhizoctonia. 2933 is Salinas x Colorado germplasm. FC123 and FC1014 are being released in 2003 by L.Panella et al. as FC301 & FC201.

Aphanomyces was evident in some entries and usually more severe in non-Salinas developed entries.

Rust and powdery mildew were moderate but were controlled with fungicide. At harvest, as powdery mildew developed, it was scored on a scale of 0 to 9.

Coefficients of correlation (r) were calculated:

	% Resist	HC	SY	RY	Powdery Mildew	Cercospora Leaf Spot	%S
Disease Index	-0.95**	-0.38**	-0.71**	-0.68**	-0.00NS	0.20**	-0.54**
% Resistant		0.34**	0.70**	0.67**	0.01NS	-0.21**	0.51**
Harvest Count			0.44**	0.43**	0.06NS	-0.09NS	0.36**
Sugar Yield				0.99**	0.14**	-0.19**	0.56**
Root Yield					0.18**	-0.19**	0.46**
Powdery Mildew						-0.15**	-0.01NS
CercosporaLeafSpot(CLS)							-0.20**

USDA ENTRIES IN BETASEED NURSERIES, SHAKOPEE & ROSEMOUNT, MN, 2003

Variety	Description	Cercospora LS			Aphanomyces		Root Aphid	
		8/22	8/29	9/03	7/16	8/09	mean	%R
Checks								
Beta 4430R		4.0	6.0	8.0	2.7	2.6	3.6	0
Monohikari		3.3	5.0	5.7	2.8	2.1	1.8	74
MM Lines								
Y290	RZM-% Y090,C1,Syn 2	3.0	3.3	5.0	3.1	1.7		
Y275	RZM-% Y075, SB x Bvm	2.3	3.0	4.3	3.5	3.1		
R221	RZM-% R021, SB x Bvm	3.0	4.7	5.0	2.7	2.6	3.1	31
Check								
CR res.ck.		2.0	2.0	2.0				
MM populations & progeny lines								
2933	RZM-% 9933 (A,aa)	3.3	4.0	5.3	3.4	2.5	3.1	21
2933-14	Inc. 0933-14, S_1	3.0	4.0	5.0			2.0	62
2933-17	Inc. 0933-17, S_1	3.3	5.3	7.3			1.3	93
2933-7	Inc. 0933-7, S_1	3.3	5.3	6.3			2.7	43
CR211	RZM-% CR011 (A,aa)	2.7	4.0	4.7				
CR009-1	RZM CR909-1aa x A	2.7	3.3	4.3				
CR211-7	Inc. CR911-7, HS	2.7	2.7	3.7				
CR210-2	Inc. CR910-2, HS	2.7	3.7	4.7				
CR110-5	Inc. CR910-5, (A,aa)	3.0	3.0	4.7				
CR110-14-2	Inc. CR910-14-2 (A,aa)	2.3	3.3	4.3				
CR112-5	Inc. CR812-5 (A,aa)	2.7	3.3	4.3				
CR214	Inc. F_1 (1241,2,3)	3.0	4.0	5.3				
01-FC1030	RZM FC(C)#1	3.0	3.3	5.0	4.6	3.5	2.8	39
mm populations								
2842	RZM 1842mmaa x A, (C842)	3.3	4.3	5.3	4.7	3.8		
01-FC123	RZM-00-FC123mmaa x A (FC301)	3.3	4.7	5.7	4.6	3.9	2.9	31
02-FC124	RZM 01-FC123H7 (A,aa)	3.7	5.0	6.0				
01-FC1014	RZM 00-FC1014mmaa x A (FC201)	3.3	4.3	5.3	4.9	4.4	3.1	28

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(cont.)

Variety	Description	Cercospora LS			Aphanomyces		Root Aphid	
		8/22	8/29	9/03	7/16	8/09	mean	%R
02-FC1015	RZM 01-FC1014H7 (A,aa)	3.0	4.3	5.7			2.7	38
CR susc. ck.		4.3	6.7	8.3				
CR res. ck.		2.0	2.0	3.0				
Aph res. ck.					2.0	1.0		
Mod Aph res. ck.					5.5	4.1		
Aph res. ck.					3.4	2.6		
Aph susc. ck.					8.5	7.4		
RA res. ck.							1.1	100
RA susc. ck.							3.1	28
LSD (.05)		0.7	1.0	1.1	1.0	0.8	-.-	---
CV		14.4	15.0	13.0	13.4	11.5	-.-	---

CLS trial at Rosemount: planted 5/3/03; inoc. 7/21/03. Scored on a scale of 0 to 9.

Aphanomyces trial at Shakopee: planted 5/18/03; treated with Tachigaren, 4 reps. Rated on 1 to 9 scale, where 1 = healthy beets and 9 = zero remaining beets after full emergence.

Root Aphid trial at Shakopee greenhouse evaluation:
Approximately 16 plants rated 1 to 4, where 1 is free from aphids and 4 is heavily infested. Ratings 1 & 2 are considered resistant. Escapes occurred on susc. ckeck.

TEST 5203. POWDERY MILDEW EVALUATION & OBSERVATION TEST, SALINAS, CA, 2003

32 entries x 6 reps., sequential
1-row plots, 11 ft. long

Planted: April 7, 2003
Harvested: October 8, 2003

Variety	Description	Source Resist	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	RJAP %	Downey Mildew %	Powdery Mildew 9/18	Powdery Mildew 10/6	Mea
US H11	11/3/99	--	8641	34.48	12.55	147	0.0	83.4	6.8	5.3	6.7	4.9
R039	Inc. R539 (C39R)	Q	10821	37.51	14.37	127	0.0	82.4	2.7	2.0	3.5	2.1
P601	PMR P401 (WB97 & 242)	Pm	10185	36.55	13.93	139	2.2	80.4	3.7	1.5	3.0	2.0
8918-12	RZM-ER-% 6918-12	Q	10979	37.09	14.80	142	0.0	81.6	1.8	1.3	1.2	1.0
R278	Inc. R178	--	10264	34.67	14.78	141	0.0	85.0	5.2	4.3	4.3	3.4
01-C37	Inc. U86-C37	--	9562	34.46	13.80	138	0.0	83.1	7.0	5.3	6.7	4.6
P227	PMR-RZM-NB P207-#(C), P127	Pm	8349	29.11	14.32	141	0.9	81.8	5.2	4.0	4.2	3.3
P228	PMR-RZM-NB P028-#(C), P128	Pm	10335	37.09	13.80	147	0.0	82.3	4.7	1.8	2.5	1.7
P229	PMR-RZM-NB P029-#(C), P129	Pm	11202	40.27	13.92	132	0.0	81.8	5.5	1.5	2.2	1.3
P230	PMR-RZM-NB P030-#(C), P130	Pm	9625	33.56	14.32	138	0.0	82.4	6.5	2.2	3.2	1.9
P207/8(Iso)	RZM-PMR-NR P007/8	Pm	8571	30.69	13.77	136	0.0	81.1	7.3	0.8	1.8	1.1
P207/8H50(Iso)	C790-15CMS x " " "	Pm	12670	42.60	14.83	144	0.0	82.7	4.2	1.8	2.7	1.9
P207/8(Sp)	Inc. P007/8	Pm	9777	34.35	14.15	145	0.0	81.8	6.7	1.8	2.7	1.7
P207/8H50(Sp)	C790-15CMS x "	Pm	12206	40.93	14.93	139	0.0	82.0	6.5	3.2	3.3	2.5
02-WB97	Inc. WB97,(C37 x Bvm-WB97)	Pm	4830	19.96	11.98	144	34.2	79.5	7.3	2.5	3.3	2.1
02-WB242	Inc. WB242,(C37 x Bvm-WB242)	Pm	6041	23.05	12.90	148	29.5	80.2	9.3	1.7	2.7	1.5
P229-8	Inc. P029-8	Pm	7418	26.61	13.90	127	0.0	79.6	7.2	2.7	3.5	2.4
P229-20	Inc. P029-20	Pm	9823	32.83	14.95	133	0.0	84.0	5.3	3.0	4.3	2.6
P230-10	Inc. P030-10	Pm	8389	28.76	14.70	139	0.0	82.3	6.7	2.0	3.3	1.8
P230-17	Inc. P030-17	Pm	11864	39.97	14.88	132	0.0	83.2	4.5	3.7	4.2	3.0
01-C37	Inc. U86-C37	--	8507	30.70	13.65	144	0.0	81.1	6.2	5.5	6.0	4.6
US H11	11/3/99	--	9177	35.07	13.02	148	0.0	82.2	5.8	5.3	5.7	4.6
R278	Inc. R178	--	9866	32.45	15.18	139	0.0	84.5	7.8	3.3	4.5	3.1
Angelina	2002	--	13032	40.83	15.90	145	0.0	85.2	5.8	8.0	8.0	7.3
P227	PMR-RZM-NB P027-#(C), P127	Pm	7645	27.01	14.12	129	2.4	81.2	5.5	2.7	3.8	2.5
P228	PMR-RZM-NB P028-#(C), P128	Pm	9204	32.67	14.02	141	0.0	80.1	8.0	2.7	3.2	2.2

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TEST 5203. POWDERY MILDEW EVALUATION & OBSERVATION TEST, SALINAS, CA, 2003

(cont.)

Variety	Description	Source Resist	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/100' No.	Bolters %	RJAP %	Downey Mildew %	Powdery Mildew 9/18	Powdery Mildew 10/6	Powdery Mildew Mean
P229	PMR-RZM-NB P209-#(C), P129	Pm	9350	32.13	14.60	136	0.0	83.1	6.7	1.3	2.3	1.5
P230	PMR-RZM-NB P030-#(C), P130	Pm	9951	34.00	14.52	150	0.0	83.5	5.7	2.0	2.8	1.8
N112	NR-RZM P912(A,aa),(915aa x P402NR)	Pm	9802	34.27	14.30	142	0.0	83.7	4.7	1.7	2.5	1.5
P207/8(Iso)	RZM-PMR-NR P007/8	Pm	9608	32.72	14.60	150	0.0	81.9	7.3	1.2	1.8	1.2
Z210	Inc. Polish %S(C)	--	11485	34.98	16.47	144	0.0	82.8	5.0	4.7	5.0	4.2
R221	RZM-% R021	--	9906	35.34	14.03	145	0.0	81.3	6.3	3.7	4.3	2.9
Mean			9659.0	33.65	14.25	140.5	2.2	82.2	5.9	3.0	3.7	2.6
LSD (.05)			1911.2	5.70	1.28	17.1	4.2	4.0	2.9	0.9	1.0	0.6
C.V. (%)			17.4	14.85	7.85	10.7	170.8	4.2	43.5	26.2	23.6	21.5
F value			6.5**	6.11**	3.74**	1.1NS	27.0**	1.0NS	2.2**	27.1**	18.8**	36.0

NOTES: Powdery mildew developed naturally and was not controlled. It was rated on a scale of 0 to 9 where 9 = 9-100% of the mature leaf area covered with mildew. The PM reactions were scored 7 times from 8/15 to 10/6/03. The mean PM value approximates the area under the disease progress curve. Type of resistance where Q = quantitative; WB97 = resistance from WB97; WB242 = resistance from WB242; Pm is allele from WB97 and/or WB242. In 2003 tests with Pm resistance, there was no evidence from the field that Pm had been defeated. Supposed Pm plants remained essentially mildew free to harvest. All lines with Pm continue to segregate Pm:pmpm so on a plot basis, no entry was scored 0 but many individual plants within these lines were 0's. Backcross recurrent parents were C37 and C78/3.

Grown under non-rhizomania conditions. Rust and downy mildew were moderate. Downy mildew was counted on 6/18/03 and represented the frequency of plants with visible DM that day. Downy mildew was ultimately more severe and wide spread than these counts indicate. At any one time, frequency and extent of downy mildew were difficult to measure.

Test 5203 was grown in an area without rhizomania on fumigated soil. See test 6403-1 for similar entries under rhizomania conditions.

P227,P228,P229,P230, and P207/8 were released as CP03,CP04,CP05,CP06, and CP07. 02-WB97 and 02-WB242 are lines derived from the first cross of Beta vulgaris susp. maritima to sugarbeet. These are the sources of resistance to powdery mildew.

A149

TEST 5303. EVALUATION OF BREEDING LINES AND POPULATIONS FOR ERWINIA & POWDERY MILDEW, SALINAS, CA, 2003

80 entries x 3 reps., sequential
1-row plots, 17.5 ft. long

Planted: April 7, 2003
Not harvested for yield

Variety	Description	Stand Count No.	Harv. Count No.	Powdery Mildew Score 06/10	09/08	09/29	Mean	Downey Mildew %	Erwinia Root Rot DI	%Healthy
Checks										
Angelina	3-19-02	29	29	8.3	7.7	7.3	7.3	33.4	24.6	52.3
Beta 4430R	9-2002	27	27	2.7	2.3	2.3	2.4	7.6	22.6	45.4
Phoenix	9-16-02	28	29	5.0	4.3	4.0	4.1	6.7	36.0	50.4
Eagle	9-16-02	25	25	5.0	4.0	4.0	4.0	32.7	39.0	43.5
Beta 4001R	9-2002	27	27	2.7	2.7	2.3	2.7	9.7	27.9	49.4
US H11	resistant check	29	27	5.3	5.0	4.7	4.9	29.8	16.5	53.0
E240	Inc. E740, (C40), susc. ck.	28	24	3.7	4.7	3.3	3.7	22.3	75.8	7.0
01-C37	Inc. U86-37, 99-C37	26	24	5.7	5.7	6.0	5.4	33.3	17.8	52.3
MM,O.P. lines										
R278	RZM R178,C78	24	26	3.7	3.3	4.3	3.5	41.9	14.3	61.2
R278-4	Inc. R078-4	27	28	2.7	3.3	3.3	2.8	29.6	12.3	71.2
Y290	RZM-% Y090	26	26	4.7	4.3	4.7	4.3	22.4	9.0	73.3
Y291	RZM Y191	26	27	4.0	3.3	4.0	3.5	31.8	15.9	72.7
Y292	Inc. FS(C),C1,Syn 1	25	25	4.0	4.0	3.7	3.6	31.3	16.4	60.1
R280/2-9	Inc. R080/2-9	24	27	6.0	5.7	6.0	5.5	12.2	7.6	72.7
Y275	RZM-% Y075	28	28	4.3	3.3	3.3	3.5	33.3	11.8	74.3
Y277	RZM Y136-Y175	23	24	4.3	3.7	4.3	3.6	38.8	8.5	77.3
R221	RZM-% R021, (C26,C27)	27	27	4.3	3.3	4.3	3.6	32.4	14.9	64.1
R276-89	RZM-% R076-89	28	28	4.0	3.0	3.7	3.1	32.7	18.6	69.2
Z210	PX of Polish 2n-ZZ	26	27	5.0	4.3	4.7	4.0	33.7	37.2	40.3
P207/8(Sp)	Inc. P007/8, (CP07)	26	26	2.7	2.3	1.7	1.9	49.1	19.3	50.3
P207/8(Iso)	RZM-PMR-NR P007/8	26	27	2.0	1.7	1.0	1.4	45.1	11.2	66.7
P227	PMR-RZM-NB P027-#(C),(CP03)	26	26	3.7	2.7	3.7	3.1	41.0	23.1	53.3
P228	PMR-RZM-NB P028-#(C),(CP04)	26	26	2.7	2.3	3.0	2.5	28.7	12.8	64.4
P229	PMR-RZM P029-#(C), (CP05)	24	25	3.0	2.0	3.0	2.4	31.2	10.7	69.4

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TEST 5303. EVALUATION OF BREEDING LINES AND POPULATIONS FOR ERWINIA & POWDERY MILDEW, SALINAS, CA, 2003

(cont.)

Variety	Description	Stand Count No.	Harv. Count No.	Powdery Mildew Score 06/10	09/08	09/29	Mean	Downey Mildew %	Erwinia Root Rot DI	%Healthy
MM.O.P. lines (cont.)										
P230	PMR-RZM P030-#(C), (CP06)	27	27	2.7	2.7	2.7	2.5	31.8	20.5	60.9
R039	Inc. R539, (C39R)	25	26	3.3	2.3	3.0	2.7	20.0	14.6	69.7
Y169	RZM-ER-% Y969, (C69)	26	28	3.3	3.0	3.7	2.9	13.6	11.5	72.9
Y167	RZM-ER-% Y967, (C67)	25	25	3.3	2.3	3.3	2.8	35.7	8.2	77.2
Multigerm, S^f,Aa populations & lines										
US H11	resistant check	27	27	5.7	5.0	5.7	5.1	34.2	12.1	57.2
E240	Inc. E740, C40, susc.check	26	24	4.7	4.0	3.0	3.6	56.5	75.5	8.3
2931	RZM-% 0931(A,aa)	27	27	2.7	3.0	2.7	2.7	30.9	26.8	49.4
2941	RZM-% 0941(A,aa)	26	26	2.7	3.0	3.0	2.6	28.2	6.6	77.3
2942	RZM-% 0942(A,aa)	26	26	3.0	2.3	2.3	2.3	30.1	10.4	65.0
2943(C)	MM,S^f,Aa, %Saa x A(C)	25	25	2.7	2.3	3.0	2.6	26.9	24.3	54.3
2921	RZM-% 0921(A,aa)	25	26	4.0	4.0	4.0	3.7	25.4	12.7	61.6
2933	RZM-% 9933(A,aa)	26	26	3.3	3.7	3.7	3.5	39.2	18.5	63.4
Z225	RZM-% Z025(A,aa)	25	26	4.0	4.3	5.0	4.1	45.3	26.0	51.6
CR211	RZM-% CR011(A,aa)	27	27	3.0	3.0	3.3	2.9	15.9	10.4	63.9
CR214	Inc. 1241-1243(C)	25	26	2.7	3.0	2.7	2.7	37.5	14.7	62.6
2930-35	RZM 1930-35aa x A, (C930-35)	26	26	3.3	3.3	3.7	3.2	53.0	38.2	39.7
2930-19	RZM 1930-19aa x A, (C930-19)	24	26	1.7	2.3	2.7	2.1	40.5	11.8	66.8
2929-45	9929-45aa x A	25	25	3.0	2.7	3.0	2.5	47.4	17.9	53.3
2936-10	RZM 0936-10aa x A	23	26	4.3	3.0	4.3	3.4	39.3	16.4	65.0
2936-16	0936-16aa x A	27	28	3.0	2.7	3.3	2.8	35.0	17.8	57.6
Nematode resistant lines & populations										
N224	RZM-NR N124(g)	27	27	3.7	2.7	3.3	3.1	45.1	24.2	53.5
N224(C)	Inc. N124-#(C)(g)	27	27	4.0	3.0	3.3	3.1	32.7	38.2	35.5
N265(C)HOM	N165HO(g) x N165-#(C)mm(g)	17	16	2.0	1.7	2.7	1.9	31.2	54.6	20.4
N265	RZM-NR N165(g)	25	23	2.3	2.0	2.7	2.1	31.1	57.8	15.0

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TEST 5303. EVALUATION OF BREEDING LINES AND POPULATIONS FOR ERWINIA & POWDERY MILDEW, SALINAS, CA, 2003

(cont.)

Variety	Description	Stand Count No.	Harv. Count No.	Powdery Mildew Score 06/10	09/08	09/29	Mean	Downey Mildew %	Erwinia DI	Root Rot %Healthy
Nematode resistant lines & populations (cont.)										
N267	RZM-NR N167(g)	25	24	2.7	1.3	3.0	2.2	30.9	44.3	29.2
N265-31HOM	N165-9HO(g) x N165-31(g)	19	19	4.3	3.3	4.0	3.6	14.2	20.4	53.5
N265-9HOM	N165-9HO(g) x RZM-NR N165-9(g)	21	18	2.7	2.3	3.3	2.5	17.3	42.4	29.3
E240	Inc. E740, C40, susc.check	26	24	3.0	2.3	3.3	2.8	54.1	77.3	6.8
Monogerm populations & lines										
US H11	resistant check	27	26	5.3	4.7	5.7	4.8	18.5	15.9	55.0
02-FC1015	RZM 01-FC1014H7	27	26	4.0	3.3	4.7	3.5	26.5	15.2	63.7
02-FC124	RZM 01-FC123H7	27	28	3.7	3.0	3.7	3.1	17.1	19.5	65.1
2843	RZM-% 0841H7	28	28	3.7	2.7	3.3	2.9	11.8	32.3	47.1
2845	RZM-% 0841H35	29	28	4.0	3.3	4.3	3.7	27.9	52.6	21.5
2846	RZM-% 0841H69	28	29	4.7	4.0	5.0	4.3	12.1	27.0	50.0
2833-5NB	NB-RZM-% 0833-5(Sp)	27	27	4.3	2.7	3.7	3.1	26.9	13.0	68.5
2833-5NBHO	1833-5HO (Iso) x "	26	27	4.3	2.3	4.0	5.2	31.3	20.7	55.6
2833-5(Sp)	RZM T-O 1833-5-#(C)mmaa x A	24	24	4.7	2.7	4.3	3.4	15.7	17.4	63.1
2833-5HO(Sp)	1833-5HO x "	25	25	4.7	3.3	4.3	3.9	22.7	24.4	49.3
2835	RZM,T-O 1835-#(C)mmaa x A	23	23	4.3	3.0	3.7	3.3	28.9	31.7	42.6
2837	RZM,T-O 1836H7-#(C)mmaa x A	23	24	5.7	4.7	6.0	5.2	18.6	16.1	59.7
2836	RZM,T-O 1836-#(C)mmaa x A	26	26	5.3	5.3	5.0	5.3	16.9	15.1	65.1
2842	RZM 1842mmaa x A	27	27	5.0	4.3	5.0	4.3	12.7	26.5	49.0
2848	RZM,T-O 1848-#(C)mmaa x A	28	28	5.3	5.0	5.0	4.8	7.0	27.4	50.0
2790	0790mmaa x A	29	29	4.3	3.3	4.7	3.8	7.5	36.7	31.8
E240	Inc. E740, C40, Susc.check	27	22	3.3	3.0	3.0	2.8	46.4	79.9	5.8
US H11	resistant check	25	24	5.3	4.7	5.3	4.8	32.7	17.4	54.8
02-C790-15CMS	C790-68CMS x C790-15	26	26	3.3	3.3	4.0	3.1	17.3	36.6	23.0
02-C790-15	Inc. C790-15	27	26	3.3	3.3	4.0	3.1	8.8	23.6	46.1

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TEST 5303. EVALUATION OF BREEDING LINES AND POPULATIONS FOR ERWINIA & POWDERY MILDEW, SALINAS, CA, 2003

(cont.)

Variety	Description	Stand Count No.	Harv. Count No.	Powdery Mildew Score 06/10	09/08	09/29	Mean	Downey Mildew %	Erwinia DI	Root Rot %Healthy
Monogerm populations & lines (cont.)										
2848-1	Inc. 9848-1	26	27	6.0	6.3	6.0	5.7	10.7	52.1	24.2
2810-17	Inc. 9810-17	28	29	2.7	3.0	3.0	2.9	22.5	58.1	21.8
2810-19	Inc. 9810-19	25	26	4.7	4.3	4.3	4.1	15.5	42.8	34.7
2835-10	Inc. 9835-10	28	26	4.3	4.3	4.3	4.3	8.2	21.7	48.1
2835-24	Inc. 9835-24	26	26	3.0	3.0	3.0	2.9	12.0	61.0	13.3
2836-13	Inc. 9836-13	28	28	2.7	3.0	2.7	3.1	19.0	13.7	61.5
2840-9	Inc. 0840-9	26	28	3.0	3.7	2.3	3.0	41.8	68.8	19.2
2869-15	Inc. 0969-15	28	27	3.7	3.0	2.7	3.0	43.5	35.7	34.2
Mean		25.9	26.0	3.9	3.4	3.8	3.5	27.9	27.0	50.5
LSD (.05)		4.2	4.9	1.2	1.2	1.1	1.1	18.7	12.2	18.9
C.V. (%)		10.0	11.6	19.7	22.6	17.8	20.3	41.5	27.9	23.2
F value		1.8**	1.8**	6.8**	6.2**	8.0**	6.5**	3.5**	17.3**	7.7**

A153

TEST 5403. ERWINIA/POWDERY MILDEW EVALUATION OF POPULATIONS & PROGENY LINES, SALINAS, CA, 2003

Planted: April 7, 2003
Not harvested for yield

80 entries x 3 reps., sequential
1-row plots, 17.5 ft. long

Variety	Description	Stand Count No.	Harv. Count No.	Powdery Mildew Score 06/10	09/08	09/29	Mean	Downey Mildew %	Erwinia DI	Root Rot %Healthy
Checks										
US H11	resistant check	27	23	5.0	5.0	5.3	5.1	21.5	14.5	46.4
E240	Inc. E740, C40, susc.ck.	24	23	4.0	5.3	4.3	4.6	44.2	63.8	22.1
Inc. S₁ progeny lines										
Z025-9	Z825-9aa x A	27	28	3.0	1.7	2.3	2.2	11.0	36.6	31.0
Z225-9	RZM Z025-9 (A,aa)	29	28	3.0	2.3	2.7	2.5	10.2	38.7	34.2
2930-35	RZM 1930-35aa x A	30	30	4.0	3.3	4.0	3.8	21.8	37.0	42.3
0930-19	8930-19aa x A	26	31	3.0	2.7	2.3	2.6	29.7	5.9	77.0
1930-19	NB 8930-19 (A,aa)	29	30	2.3	2.7	2.3	2.1	39.7	13.2	57.4
2930-19	RZM 1930-19aa x A	29	29	2.7	2.7	2.3	2.3	18.3	7.8	72.9
1927-4	RZM 9927-4aa x A	27	27	5.3	5.7	5.3	5.5	17.9	9.7	70.1
2927-4	RZM 1927-4aa x A	29	30	5.3	5.7	5.3	5.5	22.4	4.2	70.7
1924-2	RZM 9924-2aa x A	26	24	2.7	2.7	3.0	2.5	16.4	5.1	74.4
1929-4	RZM 9929-4aa x A	27	27	2.7	2.7	3.0	2.6	2.7	10.8	68.1
2929-45	9929-45aa x A	26	24	3.0	2.7	3.0	2.9	37.5	11.1	71.7
2936-10	RZM 0936-10aa x A	24	28	3.7	3.3	3.3	3.3	39.8	15.7	65.1
2936-16	0936-16aa x A	26	25	3.7	2.7	3.7	3.0	34.9	13.3	58.7
2931-3	Inc. 0931-3 (A,aa)	25	26	2.7	2.3	2.0	2.1	21.6	12.9	58.5
2931-20	Inc. 0931-20 (A,aa)	24	25	3.7	3.3	3.0	3.1	32.9	11.4	62.4
2941-20	Inc. 0941-20 (A,aa)	24	23	2.7	3.3	3.0	3.0	20.0	9.7	70.2
2933-7	Inc. 0933-7 (A,aa)	26	27	4.3	3.0	4.3	3.9	31.9	10.6	66.5
2933-14	Inc. 0933-14 (A,aa)	27	28	2.0	2.7	2.0	2.0	11.7	24.1	51.1
2933-17	Inc. 0933-17 (A,aa)	27	26	3.7	3.0	3.3	3.3	20.8	8.6	70.6
CR210-2	Inc. CR910-2 (A,aa)	23	24	5.3	4.0	4.7	4.3	46.5	14.9	51.7
CR211-7	Inc. CR911-7 (A,aa)	26	26	4.7	5.0	4.3	4.5	20.7	9.6	64.8
P207/8 (Iso)	PMR-RZM-NR P007/8	26	25	2.0	2.7	1.3	1.8	34.0	13.4	57.7

TEST 5403. ERWINIA/POWDERY MILDEW EVALUATION OF POPULATIONS & PROGENY LINES SALINAS   CA   2003

(cont.)

Variety	Description	Stand Count No.	Harv. Count No.	Powdery Mildew Score				Downey Mildew %	Erwinia DI	Erwinia Root Rot %Healthy
				06/10	09/08	09/29	Mean			
Increase of FS progeny lines										
P207/8 (Sp)	Inc. P007/8	25	25	3.0	3.0	3.0	2.8	26.2	14.4	57.1
P229-8	Inc. P029-8	25	25	3.0	3.0	2.7	2.7	37.5	19.2	59.6
P229-20	Inc. P029-20	25	24	3.3	3.0	3.7	3.3	29.3	16.2	54.0
P230-10	Inc. P030-10	26	26	2.7	3.3	2.7	2.7	27.5	19.6	65.5
E240	Inc. E740, C40, susc. check	25	24	4.3	4.7	3.3	4.1	39.9	74.7	12.5
US H11	resistant check	28	26	5.0	5.3	5.7	5.2	35.1	16.9	57.5
P230-17	Inc. P030-17	26	26	4.3	4.0	4.3	4.0	5.3	6.4	79.4
R278-4	Inc. R078-4	28	28	3.0	2.7	3.3	2.7	29.9	12.6	61.1
R278-2	Inc. R078-2	28	28	4.3	2.7	4.3	3.5	36.1	11.4	68.2
R278-7	Inc. R078-7	25	25	5.3	3.3	4.3	3.9	33.3	3.2	78.9
R278-14	Inc. R078-14	24	23	3.3	2.0	3.0	2.4	28.8	12.0	67.4
R278-16	Inc. R078-16	21	22	2.3	2.7	2.7	2.5	21.6	11.9	66.6
R278-27	Inc. R078-27	23	20	3.3	3.0	3.7	3.1	35.8	9.9	67.5
R280/2-9	Inc. R080/2-9	22	26	5.0	5.0	5.7	5.1	19.6	5.9	79.9
R280-6	Inc. R080-6	25	26	4.0	3.3	3.7	3.4	13.4	5.8	79.7
R270-18	Inc. R070-18	25	26	5.3	4.0	4.7	4.4	35.5	12.5	72.9
Y269-8	Inc. Y069-8	26	28	2.7	3.0	3.3	2.9	25.5	17.4	64.7
Y269-18	Inc. Y069-18	26	26	3.7	3.3	3.7	3.3	5.0	12.6	65.4
Y269-39	Y039-39	26	26	2.0	2.3	2.0	1.9	26.2	10.9	62.8
R276-89	RZM-% R076-89	29	30	4.3	3.0	3.3	3.2	25.2	8.2	79.7
R243-14	Inc. R043-14	26	25	2.7	2.3	2.7	2.1	62.4	12.1	64.3
Y267-21	Inc. Y067-21	24	24	4.0	2.7	3.7	3.1	11.2	2.9	83.3
Y267-24	Inc. Y067-24	27	27	3.7	2.7	3.0	2.7	19.7	7.3	79.0
Y267-34	Inc. Y067-34	25	27	3.7	3.3	4.0	3.5	7.9	9.5	79.1
Y271-14	Inc. Y071-14	26	27	4.3	4.0	5.0	4.1	30.7	12.4	65.0
Y275-16	Inc. Y075-16	26	27	5.7	6.0	5.7	5.7	24.1	35.4	48.0

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(cont.)

Variety	Description	Stand Count No.	Harv. Count No.	Powdery Mildew Score				Downey Mildew %	Erwinia Root Rot DI	Erwinia Root Rot %Healthy
				06/10	09/08	09/29	Mean			
Increase of FS progeny lines (cont.)										
US H11	Resistant check	29	27	5.3	5.0	5.3	5.0	22.8	15.2	50.5
E240	Inc. E740, C40, susc. check	25	25	3.7	4.7	4.0	4.1	45.7	67.4	8.0
Multigerm lines & populations										
2931	RZM-% 0931 (A,aa)	26	25	2.3	2.3	3.0	2.5	26.6	8.9	68.6
2941	RZM-% 0941 (A,aa)	27	26	3.0	2.7	3.7	2.9	35.0	2.6	88.2
Z225	RZM-% Z025 (A,aa)	28	28	4.0	3.3	4.7	3.7	26.5	29.5	45.6
CR211	RZM-% CR011 (A,aa)	27	25	4.3	4.0	4.0	3.9	13.4	6.8	80.5
2933	RZM-% 9933 (A,aa)	25	27	3.7	2.7	3.3	3.0	23.5	11.1	66.5
2942	RZM-% 0942 (A,aa)	27	28	2.7	2.7	3.0	2.6	7.3	6.5	73.5
CR214	Inc. 1241,2,3(C)(Aa)	22	23	3.3	3.3	3.3	3.1	31.0	11.1	73.8
2943-9	RZM Z025-9aa x composite	26	25	2.3	2.0	3.0	2.2	19.0	28.9	34.5
R181-22	Inc. R981-22	26	26	4.0	3.0	4.0	3.2	20.4	16.2	63.7
R178-6	Inc. R978-6	27	26	4.0	2.7	3.7	3.1	4.9	17.4	50.9
Y168-8	Inc. Y968-8	25	26	4.0	3.0	3.3	3.0	38.0	5.5	79.6
R180-21	Inc. R980-21	25	25	4.7	3.3	3.7	3.6	18.9	17.2	55.0
Y167-5	Inc. Y967-5	23	24	2.7	2.3	3.0	2.4	29.4	16.2	56.3
1931-56	Inc. 9931-56 (A,aa)	24	25	1.7	2.3	2.3	2.0	13.2	1.3	82.9
Z131-14	Inc. Z931-14 (A,aa)	25	24	3.0	3.0	2.0	2.5	33.6	32.8	35.7
2943-#(C)	MM,S^f,Aa,%S(C)aa x A	28	28	3.0	2.7	2.7	2.7	32.5	16.8	57.3
E240	Inc. E740,C40,susc.check	26	25	3.7	4.0	3.7	3.6	42.9	74.7	7.3
US H11	resistant check	28	25	5.3	5.0	5.7	5.1	29.3	17.3	52.6
Z210	Inc. Z010(C), Polish(gp)	27	29	5.0	4.7	4.7	4.6	30.8	27.8	46.5
Y290	RZM-% Y090	27	27	5.0	4.0	4.3	4.5	19.6	8.7	77.0
Monogerm populations										
2837	RZM,T-O 1836H7-#(C)mmaa x A	26	26	5.7	5.3	6.0	5.3	18.1	14.3	65.0
2836	RZM,T-O 1836-#(C)mmaa x A	24	23	5.0	5.0	4.7	4.8	24.2	13.6	64.2

(cont.)

Variety	Description	Stand Count No.	Harv. Count No.	Powdery Mildew Score 06/10	09/08	09/29	Mean	Downey Mildew %	Erwinia Root Rot DI	%Healthy
Monogerm populations (cont.)										
2835	RZM,T-O 1835-#(C)mmaa x A	27	26	4.3	3.7	3.3	3.5	35.5	28.9	36.6
2842	RZM 1842mmaa x A	25	24	4.0	4.7	4.3	4.1	17.8	31.0	29.7
2848	RZM,T-O 1848-#(C)mmaa x A	25	25	4.7	5.7	5.0	5.1	3.6	36.5	35.9
2790	0790mmaa x A	26	27	4.7	4.7	5.0	4.6	7.5	22.6	48.1
02-FC1015	RZM 01-FC1014H7 (A,aa)	25	26	5.0	4.7	5.0	4.5	17.6	13.1	58.1
02-FC124	RZM 01-FC123H7 (A,aa)	26	26	5.0	5.0	5.0	5.1	18.3	17.7	57.6
Mean		25.9	26.0	3.8	3.5	3.7	3.5	25.1	17.5	59.8
LSD (.05)		4.5	4.7	1.1	1.2	1.0	0.8	20.7	11.4	19.6
C.V. (%)		10.6	11.3	17.2	22.1	17.2	14.7	51.1	40.5	20.3
F value		1.1NS	1.4*	7.6**	5.8**	8.3**	12.3**	2.4**	13.4**	6.1**

TEST 203. EVALUATION OF BREEDING LINES AND POPULATIONS FOR NONBOLTING, SALINAS, 2002-2003

80 entries x 3 reps., sequential
1-row plots, 17.5 ft. long

Planted: November 13, 2002
Not harvested for yield

Variety	Description	Stand Count No.	Beets/100 No.	% Bolting 7/10	8/12	9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	9/08	Mean
Checks												
US H11	1999 production, 10/14/02	26	148	14.4	16.8	16.8	1.7	0.0	0.0	5.0	5.0	5.0
SS-NB3	Spreckels, 1996	27	154	8.6	17.6	18.8	2.3	0.0	0.0	5.0	4.0	4.5
Beta 4776R	9/02	29	164	33.0	50.1	62.3	1.3	0.0	1.1	4.0	2.0	3.0
Phoenix	9/16/02	27	152	46.6	70.2	70.2	1.0	0.0	0.0	4.3	4.0	4.2
01-SP22-0	Inc. 00-SP22-0	25	145	90.6	97.4	97.4	1.3	0.0	0.0	5.0	3.0	4.0
01-US75	Inc. 00-US75	25	145	12.3	21.4	22.7	2.0	0.0	2.6	5.7	5.0	5.3
01-C37	Inc. U86-37, 99-C37	28	158	8.5	14.5	15.7	2.0	0.0	0.0	5.7	4.7	5.2
02-US22/3	Inc. 97-US22/3	27	156	89.1	97.6	98.8	1.7	0.0	1.3	5.3	5.7	5.5
2930-19	RZM 1930-19aa x A	26	147	3.6	3.4	8.0	2.7	0.0	0.0	2.7	2.3	2.5
R178	RZM-ER-% R978	27	156	20.0	30.7	34.2	2.3	0.0	4.8	4.0	2.7	3.3
MM,O.P. lines												
R278	RZM R178,C78	20	114	38.2	45.2	52.1	3.0	0.0	7.8	2.7	3.0	2.8
R278-4	Inc. R078-4	25	143	14.3	25.4	30.7	3.0	0.0	1.4	2.3	3.0	2.7
Y290	RZM-% Y090	27	156	7.4	16.2	19.9	2.0	0.0	0.0	3.7	3.3	3.5
Y291	RZM Y191	28	162	23.7	43.2	43.2	2.0	0.0	0.0	3.7	2.3	3.0
Y292	Inc. FS(C),C1,Sym 1	28	162	21.3	35.8	36.9	1.3	0.0	1.1	4.3	2.7	3.5
R280/2-9	Inc. R080/2-9	21	122	14.6	25.6	28.7	2.3	1.5	0.0	4.3	3.7	4.0
Y275	RZM-% Y075	28	158	46.8	46.8	52.8	1.7	0.0	0.0	3.0	3.3	3.2
Y277	RZM Y136-Y175	26	147	41.8	57.5	58.7	2.3	1.2	0.0	4.3	4.7	4.5
R221	RZM-% R021, (C26,C27)	27	156	43.5	56.0	56.0	1.0	0.0	1.3	3.7	3.7	3.7
R276-89	RZM-% R076-89	29	166	18.6	22.3	22.3	2.0	1.0	1.3	3.7	3.0	3.3
Z210	PX of Polish 2n-2z	24	137	52.9	65.3	70.0	2.3	0.0	0.0	4.3	4.3	4.3
P207/8(Sp)	Inc. P007/8, (CP07)	25	145	17.3	28.2	29.6	2.3	3.8	1.4	2.0	2.0	2.0
P207/8(Iso)	RZM-PMR-NR P007/8	28	162	5.8	13.7	14.9	2.3	0.0	2.5	1.3	2.3	1.8
P227	PMR-RZM-NB P027-#(C),(CP03)	26	147	35.0	37.5	37.5	2.0	0.0	2.8	3.3	3.3	3.3
P228	PMR-RZM-NB P028-#(C),(CP04)	27	156	16.0	35.3	38.0	1.3	0.0	1.1	2.7	2.7	2.7

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TEST 203. EVALUATION OF BREEDING LINES AND POPULATIONS FOR NONBOLTING, SALINAS, 2002-2003

(cont.)

Variety	Description	Stand Count No.	Beets/100 No.	% Bolting 7/10	% Bolting 8/12	% Bolting 9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	Powdery Mildew 9/08	Powdery Mildew Mean
MM,O.P. lines (cont.)												
P229	PMR-RZM P029-#(C), (CP05)	28	162	14.5	27.8	27.8	2.0	0.0	1.1	1.7	2.7	2.2
P230	PMR-RZM P030-#(C), (CP06)	29	167	45.3	48.8	50.1	1.7	0.0	2.2	2.3	2.0	2.2
R039	Inc. R539, (C39R)	29	164	44.3	69.2	69.2	2.0	0.0	1.1	2.7	2.7	2.7
Y169	RZM-ER-% Y969, (C69)	26	148	45.5	70.0	73.6	2.0	0.0	1.2	3.0	3.3	3.2
Y167	RZM-ER-% Y967, (C67)	26	150	48.6	58.4	58.4	2.0	2.7	0.0	3.0	2.3	2.7
Multigerm, s^f,Aa populations & lines												
2931	RZM-% 0931(A,aa)	27	154	28.0	35.5	37.7	2.0	1.4	4.8	2.0	3.0	2.5
2941	RZM-% 0941(A,aa)	27	156	27.6	45.3	45.3	2.0	0.0	2.2	4.0	3.7	3.8
2942	RZM-% 0942(A,aa)	27	152	1.1	5.1	6.2	2.3	0.0	1.2	2.0	2.7	2.3
2943(C)	MM,S^f,Aa, %Saa x A(C)	27	154	16.5	28.8	30.0	2.3	0.0	2.6	3.3	3.0	3.2
2921	RZM-% 0921(A,aa)	27	156	49.0	62.9	66.3	2.3	0.0	0.0	4.3	4.3	4.3
2933	RZM-% 9933(A,aa)	30	169	25.5	31.2	32.2	2.3	0.0	2.3	4.0	4.3	4.2
Z225	RZM-% Z025(A,aa)	28	160	22.9	39.6	39.6	2.0	0.0	3.3	4.3	4.3	4.3
CR211	RZM-% CR011(A,aa)	26	147	51.6	64.0	68.2	1.7	0.0	2.6	4.0	4.3	4.2
CR214	Inc. 1241-1243(C)	26	150	31.7	49.4	49.4	1.7	0.0	3.8	3.3	3.3	3.3
2930-35	RZM 1930-35aa x A, (C930-35)	24	139	58.6	63.0	63.0	3.0	1.3	1.3	3.7	2.7	3.2
2930-19	RZM 1930-19aa x A, (C930-19)	25	141	1.3	5.3	8.0	3.0	0.0	1.3	1.7	2.3	2.0
2929-45	9929-45aa x A	23	129	33.3	43.1	43.1	3.0	0.0	1.6	3.0	3.0	3.0
2936-10	RZM 0936-10aa x A	25	145	36.3	40.2	51.0	3.0	0.0	4.5	3.7	4.0	3.8
2936-16	0936-16aa x A	26	148	5.3	13.5	17.1	2.7	0.0	0.0	1.3	2.3	1.8
Nematode resistant lines & populations												
N224	RZM-NR N124(g)	25	141	19.0	34.1	35.7	3.0	0.0	0.0	3.7	3.7	3.7
N224	Inc. N124-#(C)(g)	27	154	56.8	66.8	69.4	3.0	0.0	0.0	3.7	3.7	3.7
N265(C)	N165HO(g) x N165-#(C)mm(g)	23	129	23.5	41.0	45.5	3.0	0.0	0.0	4.0	4.0	4.0
N265	RZM-NR N165(g)	25	145	11.9	21.2	22.6	2.0	0.0	0.0	3.3	3.0	3.2
N267	RZM-NR N167(g)	25	141	17.7	29.3	32.3	2.0	1.5	0.0	2.0	1.7	1.8
N265-31HOM	N165-9HO(g) x N165-31(g)	16	91	34.0	45.0	47.7	3.7	0.0	7.3	3.0	3.0	3.0
N265-9HOM	N165-9HO(g) xRZM-NR N165-9(g)	21	120	9.8	16.2	16.2	3.0	0.0	0.0	3.0	1.7	2.3

TEST 203. EVALUATION OF BREEDING LINES AND POPULATIONS FOR NONBOLTING, SALINAS, 2002-2003

(cont.)

Variety	Description	Stand Count No.	Beets/100 No.	% Bolting 7/10	% Bolting 8/12	% Bolting 9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	Powdery Mildew 9/08	Mean
Monogerm populations & lines												
02-FC1015	RZM 01-FC1014H7	29	164	48.8	55.9	60.2	2.3	0.0	0.0	4.3	3.7	4.0
02-FC1015HO	01-FC1014H5 x "	29	164	48.5	53.3	57.8	2.3	0.0	0.0	5.0	4.0	4.5
02-FC124	RZM 01-FC123H7	29	164	12.8	19.8	20.9	2.7	0.0	0.0	4.3	4.0	4.2
02-FC124HO	01-FC123H5 x "	29	166	14.0	25.9	28.4	1.7	0.0	0.0	4.7	4.3	4.5
2843	RZM-% 0841H7	29	164	5.5	11.5	12.6	2.3	0.0	0.0	3.7	2.7	3.2
2843H5	1833-5HO x RZM-% 0841H7	28	162	1.4	6.0	6.0	2.0	0.0	0.0	3.3	3.3	3.3
2844M	RZM-% 0841H32	28	160	17.6	26.5	28.9	2.3	0.0	0.0	5.0	4.0	4.5
2844H5	1833-5HO x "	28	162	6.1	15.3	17.6	1.3	0.0	0.0	4.3	4.0	4.2
2845	RZM-% 0841H35	29	164	18.4	30.9	33.3	2.0	0.0	0.0	4.7	3.7	4.2
2845H5	1833-5HO x "	26	147	15.4	23.3	22.1	2.3	1.1	0.0	4.0	3.7	3.8
2846	RZM-% 0841H69	28	160	5.3	13.3	15.8	2.0	0.0	0.0	4.0	3.7	3.8
2846H5	1833-5HO x "	28	158	10.8	26.6	27.9	1.3	0.0	0.0	4.3	4.0	4.2
2833-5NB	NB-RZM-% 0833-5(Sp)	27	154	9.4	21.3	22.5	3.0	0.0	0.0	4.3	3.7	4.0
2833-5HONB	1833-5HO (Iso) x "	26	147	4.8	11.6	14.4	2.7	0.0	1.1	4.3	3.7	4.0
2833-5(Sp)	RZMT-O 1833-5-#(C)mmaa x A	24	135	5.7	11.6	11.6	3.7	3.0	0.0	4.3	3.3	3.8
2833-5HO(Sp)	1833-5HO x "	23	133	4.1	10.0	11.3	3.0	4.4	1.4	3.7	3.3	3.5
2835	RZM,T-O 1835-#(C)mmaa x A	25	145	39.7	51.4	51.4	2.0	6.3	0.0	4.7	3.0	3.8
2835H5	1833-5HO x "	25	145	13.1	29.9	32.8	2.0	0.0	0.0	4.3	3.3	3.8
2837	RZM,T-O 1836H7-#(C)mmaa x A	24	135	13.9	19.6	21.0	2.7	0.0	1.3	5.7	4.0	4.8
2837H56	1836HO x "	27	154	6.5	15.3	16.6	2.0	0.0	0.0	5.0	4.0	4.5
2837H5	1833-5HO x "	26	148	19.6	30.9	34.9	2.0	0.0	0.0	5.3	3.7	4.5
2836	RZM,T-O 1836-#(C)mmaa x A	26	150	3.8	6.2	7.6	1.7	1.4	0.0	5.3	4.3	4.8
2836HO	1833-5HO x RZM,T-O 1836-#(C)mmaa x A	25	143	7.1	13.9	15.2	2.3	1.5	1.5	5.7	4.3	5.0
2842	RZM 1842mmaa x A	26	150	14.6	29.8	32.4	2.3	1.3	0.0	6.0	4.0	5.0

TEST 203. EVALUATION OF BREEDING LINES AND POPULATIONS FOR NONBOLTING, SALINAS, 2002-2003

(cont.)

Variety	Description	Stand Count No.	Beets/100 No.	% Bolting 7/10	8/12	9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	9/08	Mean
Monogerm populations & lines (cont.)												
2842HO	1842HO(A) x "	25	145	6.5	10.6	14.6	2.0	2.6	0.0	4.3	3.7	4.0
2842H5	0833-5HO x "	25	141	7.7	19.7	21.1	2.7	1.4	0.0	4.3	3.3	3.8
2842H50	C790-15CMS x "	26	150	13.8	32.7	35.2	2.3	1.2	0.0	4.7	4.0	4.3
2848	RZM,T-O 1848-#(C)mmaa x A	25	141	8.4	14.2	15.7	3.3	0.0	0.0	4.0	4.0	4.0
2848H5	0833-5HO x "	27	152	11.3	16.0	18.4	2.3	0.0	0.0	4.7	4.3	4.5
2790	0790mmaa x A	25	143	6.4	10.5	11.9	2.3	3.8	0.0	3.7	3.7	3.7
2790H5	1833-5HO x A	24	135	8.4	13.9	13.9	2.3	2.8	0.0	4.3	4.0	4.2
2790H7	1833-5aa x A	25	141	7.8	18.7	21.4	2.3	4.0	0.0	4.0	3.7	3.8
02-C790-15CMS												
	99-790-68CMS x 00-790-15	27	156	6.8	15.7	15.7	2.0	1.4	0.0	3.7	2.7	3.2
02-C790-15	Inc. 00-790-15	29	166	4.5	23.7	24.8	1.7	1.1	0.0	2.3	3.0	2.7
2848-1	Inc. 9848-1	30	169	5.5	9.0	9.0	2.0	2.3	0.0	6.7	5.7	6.2
2810-17	Inc. 9810-17	29	164	1.1	1.1	1.1	2.3	2.3	0.0	3.3	2.3	2.8
2810-19	Inc. 9810-19	26	150	5.1	22.8	24.2	2.3	1.3	0.0	5.3	4.3	4.8
2835-10	Inc. 9835-10	28	162	18.9	30.9	32.1	2.7	1.1	1.1	4.3	3.7	4.0
2835-24	Inc. 9835-24	29	167	4.5	6.8	6.8	2.3	0.0	0.0	3.3	2.7	3.0
2836-13	Inc. 9836-13	28	162	0.0	0.0	0.0	2.7	0.0	2.8	2.7	3.3	3.0
2840-9	Inc. 0840-9	28	158	0.0	0.0	0.0	3.3	0.0	9.9	3.0	2.3	2.7
2869-15	Inc. 0969-15	29	164	0.0	1.1	1.1	3.0	1.1	1.1	3.3	1.7	2.5
Components of high %S polycross												
2943-9	RZM Z025-9aa x Composite	27	154	13.4	19.0	20.1	3.0	1.3	4.0	2.0	1.7	1.8
2943-19	1930-19aa x "	28	158	3.5	8.3	8.3	2.3	1.2	0.0	2.7	1.7	2.2
2943-35	1930-35aa x "	28	160	42.6	55.9	55.9	2.3	0.0	0.0	4.3	3.0	3.7
2943-14	RZM Z131-14aa x "	25	141	26.1	35.5	35.5	2.3	0.0	3.9	3.0	2.3	2.7
2943-18	RZM Z131-18aa x "	23	129	21.7	30.5	32.1	2.7	0.0	0.0	3.3	2.3	2.8
2943-20	RZM Z131-20aa x "	28	162	35.9	55.7	57.1	2.0	0.0	3.2	3.3	2.0	2.7
2943H5	0833-5HO x Composite	28	158	14.1	17.5	22.8	2.7	0.0	1.1	4.0	3.0	3.5

TEST 203. EVALUATION OF BREEDING LINES AND POPULATIONS FOR NONBOLTING, SALINAS, 2002-2003

(cont.)

Variety Description	Stand Count No.	Beets/ 100 No.	% Bolting 7/10	8/12	9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	9/08	Mean
Mean	26.4	150.7	21.1	30.6	32.4	2.3	0.6	1.1	3.8	3.3	3.6
LSD (.05)	4.3	24.3	13.4	15.8	15.4	0.9	2.8	4.6	1.6	1.3	1.2
C.V. (%)	10.0	10.0	39.7	32.1	29.5	23.4	275.0	265.7	25.2	24.3	21.3
F value	2.2**	2.2**	14.8**	13.4**	14.7**	3.1**	1.4*	1.2NS	3.7**	3.5**	4.3**

TEST 303. EVALUATION OF SELECTED PROGENY LINES FOR NONBOLTING, SALINAS, 2002-2003

Planted: November 13, 2002
Not harvested for yield

50 entries x 3 reps., sequential
1-row plots, 17.5 ft. long

Variety	Description	Stand Beets/ Count No.	Beets/ 100 No.	% Bolting 7/10	% Bolting 8/12	% Bolting 9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	Powdery Mildew 9/08	Powdery Mildew Mean
Checks												
02-US22/3	Inc. 97-US22/3	27	156	94.2	96.5	96.5	2.0	1.3	0.0	5.0	5.3	5.2
Z210	PX of Z#(C)	26	150	40.5	54.7	59.9	2.3	3.9	0.0	5.0	4.7	4.8
Increase of S₁ lines												
0930-19	8930-19aa x A	27	156	1.2	2.3	2.3	2.3	0.0	0.0	2.7	2.0	2.3
1930-19	NB 8930-19(A,aa)	28	160	1.2	3.7	3.7	2.7	0.0	1.2	3.3	2.0	2.7
2930-19	RZM 1930-19aa x A	26	147	0.0	1.3	1.3	2.3	1.3	5.3	1.7	1.3	1.5
Z025-9	Z825-9aa x A	25	145	23.0	46.2	47.4	2.0	0.0	0.0	2.3	2.0	2.2
Z225-9	RZM Z025-9	27	152	17.5	31.2	33.7	2.0	0.0	1.2	3.3	2.3	2.8
2930-35	RZM 1930-35aa x A	28	158	57.2	64.3	66.9	2.0	0.0	1.3	5.0	3.7	4.3
1927-4	RZM 9927-4aa x A	24	137	25.9	40.6	43.2	2.0	0.0	0.0	6.0	4.0	5.0
2927-4	RZM 1927-4	26	147	6.2	16.3	26.8	2.0	0.0	0.0	5.3	4.7	5.0
1924-2	RZM 9924-2aa x A	14	78	12.8	12.8	17.9	2.7	9.6	0.0	2.3	2.7	2.5
1929-4	RZM 9929-4aa x A	27	154	8.8	13.6	13.6	2.3	0.0	2.7	3.0	2.0	2.5
2929-45	9929-45aa x A	27	152	29.8	37.4	37.4	2.0	0.0	1.6	4.0	2.3	3.2
2936-10	RZM 0936-10aa x A	27	156	26.9	29.3	36.6	1.7	1.2	9.6	4.0	3.0	3.5
2936-16	0936-16aa x A	26	148	2.5	5.0	11.4	2.3	0.0	0.0	2.3	2.3	2.3
2931-3	Inc. 0931-3	23	133	26.2	40.7	42.3	2.0	2.8	1.3	2.3	1.3	1.8
2931-20	Inc. 0931-20	25	143	2.5	14.3	14.3	2.0	2.6	4.0	2.7	2.7	2.7
2941-20	Inc. 0941-20	27	152	5.0	6.3	6.3	2.0	0.0	1.2	2.7	2.7	2.7
2933-7	Inc. 0933-7	29	167	3.4	9.1	9.1	1.7	0.0	1.1	3.3	3.3	3.3
2933-14	Inc. 0933-14	28	160	10.8	18.9	20.1	2.3	0.0	0.0	2.0	2.7	2.3
2933-17	Inc. 0933-17	26	147	24.8	40.7	43.1	2.3	0.0	1.2	4.0	5.0	4.5
CR210-2	Inc. CR910-2	25	143	71.0	83.5	83.5	2.0	0.0	6.2	5.7	5.3	5.5
CR211-7	Inc. CR911-7	26	148	21.5	42.7	42.7	2.0	0.0	0.0	3.7	3.3	3.5

TEST 303. EVALUATION OF SELECTED PROGENY LINES FOR NONBOLTING, SALINAS, 2002-2003

(cont.)

Variety	Description	Stand Beets/ Count 100 No.	No.	% Bolting 7/10	% Bolting 8/12	% Bolting 9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	Powdery Mildew 9/08	Powdery Mildew Mean
Increase of FS progeny lines												
P207/8(Iso)	RZM-PMR-NR P007/8	28	160	10.8	12.0	13.1	1.7	1.1	1.2	1.7	2.3	2.0
P207/8(Sp)	Inc. P007/8	26	150	8.9	14.1	14.1	1.7	5.1	0.0	2.0	2.3	2.2
P229-8	Inc. P029-8	28	158	14.3	19.1	19.1	2.0	0.0	3.6	2.7	3.3	3.0
P229-20	Inc. P029-20	27	156	12.8	22.3	24.7	1.7	1.3	2.4	3.0	3.0	3.0
P230-10	Inc. P030-10	29	164	6.2	17.3	20.6	2.0	0.0	2.2	1.3	2.0	1.7
P230-17	Inc. P030-17	28	160	2.7	2.7	2.7	2.0	1.2	0.0	2.7	3.0	2.8
R278-4	Inc. R078-4	27	154	15.5	20.2	31.5	2.0	0.0	2.2	2.7	2.7	2.7
R278-2	Inc. R078-2	29	166	2.2	10.2	11.3	1.7	0.0	7.9	3.7	3.3	3.5
R278-7	Inc. R078-7	28	158	21.2	29.9	29.9	2.0	0.0	0.0	3.3	3.7	3.5
R278-14	Inc. R078-14	26	148	1.2	2.5	2.5	2.0	0.0	0.0	2.0	1.7	1.8
R278-16	Inc. R078-16	27	152	21.5	27.7	30.2	2.0	0.0	1.2	2.3	2.7	2.5
R278-27	Inc. R078-27	26	150	0.0	2.6	0.0	2.0	0.0	2.6	3.0	2.3	2.7
R280/2-9	Inc. R080/2-9	24	139	9.7	23.1	26.1	2.0	1.2	0.0	5.0	3.7	4.3
R280-6	Inc. R080-6	28	158	18.6	25.7	26.9	1.3	0.0	2.4	4.0	2.7	3.3
R270-18	Inc. R070-18	25	141	0.0	2.7	4.0	2.0	0.0	1.4	3.7	3.3	3.5
Y269-8	Inc. Y069-8	27	152	21.2	35.2	37.6	1.7	0.0	2.5	4.3	2.3	3.3
Y269-18	Inc. Y069-18	29	164	15.4	17.7	22.5	2.0	1.1	10.2	3.3	3.3	3.3
Y269-39	Inc. Y069-39	26	148	24.1	42.8	49.7	2.3	0.0	12.2	2.7	2.0	2.3
Y276-89	RZM-% R076-89	27	154	11.4	15.1	17.7	1.7	0.0	0.0	2.7	2.3	2.5
R243-14	Inc. R043-14	28	158	48.4	48.4	48.4	1.7	0.0	2.3	3.0	2.3	2.7
Y267-21	Inc. Y067-21	28	158	50.3	53.0	56.6	1.7	0.0	1.1	4.0	3.0	3.5
Y267-24	Inc. Y067-24	26	150	2.5	3.7	3.7	2.0	0.0	1.3	3.3	2.7	3.0
Y267-34	Inc. Y067-34	28	162	32.5	53.9	53.9	2.0	0.0	0.0	3.3	2.0	2.7
Y271-14	Inc. Y071-14	28	162	0.0	5.8	5.8	2.0	0.0	4.4	3.0	2.7	2.8
Y275-16	Inc. Y075-16	26	148	10.3	15.4	18.0	2.0	0.0	0.0	5.3	4.7	5.0
R176-89-5	RZM R076-89-5	26	150	17.2	25.0	27.7	2.3	0.0	0.0	2.7	2.7	2.7
R176-89-5-4	Inc. R976-89-5-4	26	148	0.0	0.0	1.2	2.3	0.0	1.4	2.0	1.7	1.8

TEST 303. EVALUATION OF SELECTED PROGENY LINES FOR NONBOLTING, SALINAS, 2002-2003

(cont.)

Variety Description	Stand Count No.	Beets/100 No.	% Bolting 7/10	% Bolting 8/12	% Bolting 9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	Powdery Mildew 9/08	Powdery Mildew Mean
Mean	26.5	151.2	17.8	25.2	27.2	2.0	0.7	2.0	3.3	2.9	3.1
LSD (.05)	3.6	20.4	13.8	17.4	17.6	0.7	2.2	6.1	1.4	1.3	1.2
C.V. (%)	8.3	8.3	47.6	42.6	40.0	21.7	203.2	185.8	26.8	28.8	23.2
F value	3.2**	3.2**	15.4**	12.1**	12.1**	1.1NS	4.5**	1.7*	4.8**	4.2**	5.7**

TEST 103. EVALUATION OF EXPERIMENTAL HYBRIDS FOR NONBOLTING, SALINAS, 2002-2003

80 entries x 3 reps., sequential
1-row plots, 17.5 ft. long

Planted: November 13, 2002
Not harvested for yield

Variety	Description	Stand Count No.	Beets/100 No.	% Bolting 7/10	8/12	9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	9/08	Mean
Checks												
SS-NB3	4/96	28	158	2.6	9.2	11.8	1.7	0.0	0.0	4.7	5.0	4.8
Monohikari	3/1/00	27	152	97.6	100.0	100.0	2.7	0.0	4.8	5.0	5.0	5.0
US H11	10/4/02	28	160	9.7	14.2	14.2	2.3	0.0	2.2	4.3	5.3	4.8
Phoenix	9/16/02	27	154	56.5	77.9	79.2	1.7	0.0	0.0	4.0	3.7	3.8
Eagle	9/16/02	26	148	34.7	59.0	60.4	2.0	0.0	2.3	4.7	3.7	4.2
HM-E17	3/21/02	29	164	96.6	98.9	100.0	1.7	0.0	0.0	4.7	4.7	4.7
Angelina	3/19/02	29	164	25.4	41.5	42.7	2.0	0.0	0.0	5.3	5.7	5.5
Beta 4776R	9/02	30	171	25.2	50.9	56.4	2.3	0.0	0.0	3.0	2.0	2.5
Beta 4430R	9/02	29	167	32.9	64.7	68.1	1.3	0.0	3.4	2.7	3.3	3.0
Beta 4001R	9/02	30	169	11.2	37.0	38.1	2.0	0.0	0.0	2.0	2.0	2.0
Hybrids with C833-5CMS												
2927-4H5	1833-5HO x RZM 1927-4	23	129	5.8	10.6	14.8	2.7	0.0	0.0	3.7	3.7	3.7
Z225-9H5	1833-5HO x RZM 2025-9	27	156	4.9	12.0	12.0	1.3	0.0	0.0	2.7	2.0	2.3
Y277H5	0833-5HO x RZM R136-Y175(C)	26	147	22.3	33.9	43.0	2.0	2.6	0.0	4.0	4.7	4.3
R278H5	1833-5HO x RZM R178	26	147	20.8	24.8	26.1	2.3	1.3	0.0	3.3	4.0	3.7
Z210H5	0833-5HO x Z#(C)	26	147	25.2	42.0	44.3	2.0	2.6	0.0	4.3	4.7	4.5
P207/8H5	0833-5HO x P007/8	27	152	8.5	14.3	14.3	2.3	2.4	0.0	3.3	3.7	3.5
Y291H5	x RZM Y191	24	135	18.5	29.8	31.2	2.3	1.4	0.0	3.3	4.0	3.7
R278-4H5	x R078-4	28	160	1.1	15.6	16.7	2.3	2.5	3.3	3.0	3.3	3.2
R280/2-9H5	x R080/2-9	29	164	7.5	18.0	18.0	1.7	1.3	0.0	4.3	4.7	4.5
2943H5	x MM,S^f,Aa,%S(C)	28	158	15.5	25.8	26.9	2.3	0.0	0.0	3.0	3.3	3.2
2936-10H5	0833-5HO x RZM 0936-10	27	152	13.4	14.6	16.1	2.3	2.4	1.2	3.3	3.3	3.3
2936-16H5	x 0936-16	25	145	2.9	5.5	5.5	2.3	2.3	0.0	1.3	2.3	1.8
2930-35H5	x RZM 1930-35	25	145	8.1	26.9	28.2	3.0	0.0	0.0	4.3	5.0	4.7

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TEST 103. EVALUATION OF EXPERIMENTAL HYBRIDS FOR NONBOLTING, SALINAS, 2002-2003

(cont.)

Variety	Description	Stand Count No.	Beets/100 No.	% Bolting 7/10	% Bolting 8/12	% Bolting 9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	Powdery Mildew 9/08	Powdery Mildew Mean
Hybrids with C833-5CMS (cont.)												
2930-19H5	0833-5HO x RZM 1930-19	26	150	2.8	6.9	9.4	2.7	1.4	0.0	2.7	4.0	3.3
2929-45H5	x 9929-45	26	147	11.2	15.5	17.7	2.7	1.4	1.1	3.0	3.3	3.2
Hybrids with C790-15CMS												
R278H50	C790-15CMS x RZM R178	27	154	27.7	36.8	39.3	2.7	0.0	0.0	3.3	3.3	3.3
R278-4H50	x R078-4	28	162	6.0	16.5	20.0	2.7	2.4	0.0	2.0	2.3	2.2
Y290H50	x RZM-% Y090	26	150	11.3	32.5	33.8	2.3	0.0	0.0	2.7	3.0	2.8
Y291H50	x RZM Y191	26	150	16.1	32.6	32.6	2.0	2.6	0.0	2.7	3.0	2.8
R280/2-9H50	x R080/2-9	26	147	17.5	33.4	37.2	2.3	1.3	0.0	3.0	3.3	3.2
Y275H50	x RZM-% Y075	26	147	21.4	30.2	31.3	2.0	0.0	0.0	3.0	4.0	3.5
Y277H50	x RZM R136-Y175(C)	27	156	32.1	39.2	44.5	2.3	0.0	0.0	3.3	4.0	3.7
R276-89H50	x RZM-% R076-89	31	175	7.6	9.9	9.9	1.0	2.5	0.0	2.7	3.3	3.0
Z210H50	x Z(C), Polish ZZ	27	154	29.6	44.2	45.3	1.7	0.0	0.0	4.7	4.7	4.7
P207/8H50(sp)	x P007/8	26	148	11.4	16.0	23.4	2.3	0.0	0.0	2.7	2.0	2.3
P207/8H50(Iso)	x RZM-PMR-NR P007/8	28	158	2.6	13.4	13.4	2.3	0.0	0.0	2.0	2.3	2.2
2942H50	x RZM-% 0942	26	147	1.3	3.9	7.8	2.0	0.0	0.0	2.3	2.7	2.5
2943H50	x MM,s[f],Aa,%S(C)	24	139	15.3	32.7	35.5	2.7	0.0	0.0	1.3	3.0	2.2
2933H50	x RZM-% 9933	25	145	10.6	20.3	24.5	2.7	0.0	0.0	2.3	4.0	3.2
2930-35H50	x RZM 1930-35	25	145	15.8	29.5	29.5	3.0	1.4	0.0	3.7	3.0	3.3
2930-19H50	x RZM 1930-19	28	158	6.2	8.8	12.7	2.7	0.0	0.0	1.7	2.0	1.8
2929-45H50	x 9929-45	28	160	18.2	23.2	23.2	2.0	0.0	0.0	2.3	2.3	2.3
2936-10H50	x RZM 0936-10	29	167	11.2	22.5	22.5	1.7	0.0	0.0	2.3	3.0	2.7
2936-16H50	C790-15CMS x 0936-16	27	156	7.3	16.8	19.4	1.7	1.2	0.0	2.7	3.0	2.8
US H11	10/14/02	32	181	9.5	16.8	16.8	1.7	0.0	0.0	3.7	4.7	4.2

TEST 103. EVALUATION OF EXPERIMENTAL HYBRIDS FOR NONBOLTING, SALINAS, 2002-2003

(cont.)

Variety	Description	Stand Count No.	Beets/100 No.	% Bolting 7/10	8/12	9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	9/08	Mean
Nematode Resistant hybrids												
N224H98	N165-9H50(g) x RZM-NR N124	29	166	8.8	19.1	19.1	2.0	0.0	0.0	2.0	2.3	2.2
N224H94	N165-9HO(g) x N124-#(C)(g)	28	160	32.1	34.4	50.0	2.0	0.0	0.0	3.0	3.3	3.2
R278H95	N165-#(g)aa x RZM R178	25	141	27.5	36.5	36.5	2.7	0.0	1.6	3.3	4.0	3.7
R278H96	N165HO (w/o g) x RZM R178	26	150	14.3	22.3	24.8	2.0	0.0	1.3	2.7	3.0	2.8
R278H97	N167HO (w/o g) x RZM R178	24	139	23.1	33.1	38.2	2.3	1.3	2.0	2.3	2.3	2.3
F1 hybrids												
R278H31	RZM 1931aa x RZM R178	26	148	26.0	40.3	40.3	2.3	0.0	0.0	2.7	2.3	2.5
R278H41	RZM 1941aa x " "	26	148	25.7	37.2	41.4	2.7	0.0	0.0	2.7	3.0	2.8
R278H25	Z125aa x " "	23	133	40.0	47.7	47.7	2.7	1.3	1.7	3.0	3.3	3.2
R278H40	1930-35aa x " "	25	143	29.0	35.8	35.8	3.0	0.0	1.2	3.0	3.3	3.2
R278H23	Z025-9aa x " "	25	145	21.9	32.2	32.2	3.0	0.0	1.5	3.3	2.7	3.0
Y291H31	RZM 1931aa x RZM Y191	26	148	14.3	26.2	26.2	2.7	1.2	3.6	3.7	3.7	3.7
Y291H41	RZM 1941aa x " "	29	166	11.6	24.5	25.7	2.3	0.0	1.1	3.0	4.0	3.5
Y291H25	RZM Z125aa x " "	28	162	28.5	35.9	36.9	2.7	0.0	1.2	2.7	3.0	2.8
Y291H11	RZM CR111aa x " "	28	162	29.6	34.5	35.6	2.3	1.1	0.0	2.3	3.0	2.7
Y291H23	Z025-9aa x " "	27	156	16.3	26.3	26.3	2.7	0.0	0.0	3.3	3.0	3.2
R78 topcross hybrids												
R278H50	C790-15CMS x RZM R178	28	158	26.3	29.6	29.6	2.7	0.0	0.0	3.0	3.0	3.0
R278H5	1833-5HO x " "	25	143	13.1	28.9	30.5	2.7	0.0	0.0	3.3	3.0	3.2
R278H6	0833-5H50 x " "	26	147	14.6	23.4	24.8	3.0	1.4	1.3	3.0	3.7	3.3
R278H2	9831-3HO x " "	25	141	21.9	28.5	28.5	3.0	1.3	0.0	3.3	3.0	3.2
R278H27	9831-4HO x " "	26	147	21.0	28.7	29.9	2.3	0.0	1.2	2.7	3.0	2.8
R278H28	0831-4-7HO x RZM R178	25	145	9.5	17.7	17.7	2.7	0.0	0.0	3.0	3.3	3.2
R278H29	0831-4-10HO x " "	26	147	20.6	24.5	25.8	2.3	0.0	1.2	2.3	3.0	2.7
R278H77	1833-5-8HO x " "	25	141	12.2	21.8	24.4	2.7	0.0	1.3	3.0	3.7	3.3
R278H78	1833-5-11HO x " "	25	143	19.4	28.8	28.8	2.7	1.3	0.0	3.0	4.0	3.5
R278H46	9869-6HO x " "	24	139	23.7	28.0	29.5	3.0	0.0	0.0	3.7	4.7	4.2

TEST 103. EVALUATION OF EXPERIMENTAL HYBRIDS FOR NONBOLTING, SALINAS, 2002-2003

(cont.)

Variety	Description	Stand Count No.	Beets/100 No.	% Bolting 7/10	% Bolting 8/12	% Bolting 9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	Powdery Mildew 9/08	Powdery Mildew Mean
R78 topcross hybrids (cont.)												
R278H45	9867-1HO x R178	26	147	35.0	47.0	47.0	3.0	1.4	0.0	3.0	3.3	3.2
R278H73	01-FC123H5 x "	25	143	10.7	27.1	27.1	3.0	1.2	0.0	4.3	4.3	4.3
R278H74	01-FC1014H5 x "	25	145	28.3	34.3	36.0	2.3	0.0	2.4	3.7	4.0	3.8
R278H62	0836-1H5 x "	23	131	20.8	27.9	31.9	2.7	0.0	1.3	3.0	3.0	3.0
R278H63	0836-7H5 x "	25	141	16.7	19.1	20.3	3.0	1.1	0.0	2.3	2.3	2.3
R278H64	0834-2H5 x "	28	162	14.1	20.0	22.4	2.7	2.5	2.4	3.7	4.0	3.8
R278H67	0837-6H5 x "	28	162	20.2	28.4	29.5	2.7	0.0	2.6	3.3	3.7	3.5
R278H75	1835-11H5 x "	28	162	26.6	36.0	37.3	2.7	0.0	0.0	4.3	4.3	4.3
R278H76	1835-26H5 x R178	26	147	32.6	51.6	52.8	3.0	0.0	1.6	4.3	4.0	4.2
2930-19H5	0833-5HO x RZM 1930-19	26	150	3.6	13.1	13.1	2.3	0.0	0.0	2.7	3.0	2.8
Mean		26.6	151.8	19.7	29.7	31.5	2.4	0.6	0.6	3.2	3.5	3.3
LSD (.05)		4.7	26.6	13.6	15.8	15.8	0.8	2.7	3.3	1.5	1.3	1.1
C.V. (%)		10.9	10.9	42.8	33.0	31.1	22.0	273.5	331.0	29.0	22.4	20.6
F value		1.1NS	1.1NS	11.0**	9.5**	9.7**	2.3**	0.9NS	0.8NS	2.5**	3.6**	4.2**

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50 entries x 3 reps., sequential
1-row plots, 17.5 ft. long

Planted: November 13, 2002
Not harvested for yield

Variety	Description	Stand Count No.	Beets/ 100 No.	% Bolting 7/10	8/12	9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	9/08	Mean
Checks												
US H11	1999 production	28	162	12.8	21.0	21.0	1.7	0.0	0.0	4.7	5.0	4.8
Z210H50	C790-15CMS x Polish(C)	26	150	42.2	58.6	58.6	1.7	0.0	1.3	4.7	5.0	4.8
Hybrids from increase of S₁ lines												
0930-19H50	C790-15CMS x 8930-19	28	160	13.3	20.4	22.8	1.3	0.0	2.3	2.7	2.7	2.7
1930-19H50	x NB 8930-19	29	167	1.1	3.3	6.6	1.3	0.0	1.2	2.7	2.7	2.7
2930-19H50	x RZM 1930-19	28	162	7.2	16.6	20.2	1.7	0.0	1.1	2.3	2.3	2.3
Z025-9H50	x Z825-9	29	164	17.4	34.9	36.1	1.3	0.0	0.0	2.7	2.7	2.7
Z225-9H5	C833-5HO x RZM Z025-9	26	150	1.2	8.9	10.2	2.0	0.0	0.0	2.7	3.0	2.8
2930-35H50	C790-15CMS x RZM 1930-35	24	137	18.6	33.5	35.9	2.0	0.0	0.0	4.0	3.3	3.7
1927-4H50	x RZM 9927-4	25	145	32.6	48.3	52.3	2.0	0.0	0.0	4.7	4.7	4.7
2927-4H5	C833-5HO x RZM 1927-4	17	95	4.9	22.5	27.0	2.7	0.0	0.0	4.7	4.0	4.3
1924-2H50	C790-15CMS x RZM 9924-2	28	162	14.9	28.7	29.8	1.3	2.2	5.3	2.7	3.7	3.2
1929-4H50	x RZM 9929-4	29	164	16.4	21.1	21.1	1.3	0.0	2.4	3.0	3.0	3.0
2929-45H50	x 9929-45	29	167	15.8	20.3	21.5	1.3	0.0	1.2	3.0	3.7	3.3
2936-10H50	x RZM 0936-10	28	158	16.3	33.4	35.9	2.0	2.6	2.2	3.3	4.0	3.7
2936-16H50	x RZM 0936-16	28	158	13.0	21.4	23.7	1.7	0.0	0.0	3.0	3.0	3.0
2931-3H50	x 0931-3	28	160	15.4	27.3	32.1	1.0	1.1	2.4	2.0	2.0	2.0
2931-20H50	x 0931-20	18	101	9.8	33.0	40.8	2.0	0.0	3.9	3.3	3.7	3.5
2941-20H50	x 0941-20	29	164	16.2	32.4	34.8	1.7	0.0	0.0	4.0	4.7	4.3
2933-7H50	x 0933-7	24	135	11.0	27.3	27.3	2.0	0.0	3.3	2.3	4.7	3.5
2933-14H50	x 0933-14	28	158	12.9	23.0	25.3	1.3	0.0	0.0	1.7	4.0	2.8
2933-17H50	x 0933-17	20	112	17.5	31.4	31.4	2.0	0.0	2.1	3.0	5.0	4.0
CR210-2H50	x CR910-2	19	108	68.7	86.4	86.4	2.0	0.0	0.0	4.0	5.0	4.5
CR211-7H50	x CR911-7	21	118	9.4	27.4	31.1	2.0	0.0	0.0	3.3	3.0	3.2

(cont.)

Variety	Description	Stand Count No.	Beets/100 No.	% Bolting 7/10	% Bolting 8/12	% Bolting 9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	Powdery Mildew 9/08	Mean
Hybrids from increase of FS progeny lines												
P207/8H50(Iso)	C790-15CMS x RZM-PMR-NR P007/8	27	154	15.8	24.3	24.3	1.7	0.0	0.0	1.3	2.3	1.8
P207/8H50(Sp)	x P007/8	29	166	8.2	16.1	18.4	1.7	0.0	1.2	2.0	2.7	2.3
P229-8H50	x P029-8	28	162	44.4	53.0	54.1	1.3	0.0	0.0	3.0	3.7	3.3
P229-20H50	x P029-20	27	154	20.2	29.7	29.7	1.3	0.0	0.0	2.0	4.0	3.0
P230-10H50	x P030-10	28	162	14.0	23.6	29.3	1.7	0.0	0.0	2.7	3.3	3.0
p230-17H50	x P030-17	29	167	1.1	1.1	1.1	1.0	0.0	0.0	3.3	3.7	3.5
R078-4H50	x R078-4	26	147	6.5	22.2	24.9	1.7	0.0	0.0	2.3	3.3	2.8
R078-2H50	x R078-2	28	162	15.2	28.1	32.9	1.3	0.0	1.1	3.0	3.3	3.2
R078-7H50	x R078-7	29	164	10.4	18.4	18.4	1.7	0.0	0.0	3.0	2.3	2.7
R078-14H50	x R078-14	26	150	2.6	12.7	13.9	1.7	1.3	0.0	2.0	2.0	2.0
R078-16H50	x R078-16	27	152	23.4	32.4	33.6	1.3	0.0	2.5	2.7	2.7	2.7
R078-27H50	x R078-27	26	150	5.2	16.5	16.5	2.0	0.0	0.0	2.7	3.0	2.8
R280/2-9H50	C790-15CMS x R080/2-9	27	156	14.6	27.9	27.9	2.0	0.0	0.0	4.3	3.0	3.7
R280-6H50	x R080-6	27	154	24.0	37.1	41.0	1.7	0.0	0.0	3.7	3.0	3.3
R270-18H50	x R070-18	19	108	0.0	9.7	12.7	2.3	0.0	1.5	2.7	2.3	2.5
Y069-8H50	x Y069-8	27	154	21.5	30.9	32.3	1.0	0.0	0.0	3.7	3.3	3.5
Y069-18H50	x Y069-18	30	171	4.5	23.3	23.3	1.0	0.0	0.0	3.3	3.3	3.3
Y069-39H50	x Y069-39	28	160	18.1	39.8	42.0	1.3	0.0	0.0	2.7	2.0	2.3
Y276-89H50	x RZM-% R076-89	23	133	11.5	14.5	14.5	2.0	0.0	0.0	2.3	2.7	2.5
R043-14H50	x R043-14	27	154	30.3	58.3	58.3	2.0	0.0	3.6	3.3	2.7	3.0
Y067-21H50	x Y067-21	26	147	28.8	48.5	44.5	1.3	1.2	1.2	3.0	2.3	2.7
Y067-24H50	x Y067-24	28	162	2.3	16.2	16.2	2.0	0.0	1.2	4.0	3.0	3.5
Y067-34H50	x Y067-34	29	164	14.0	22.2	22.2	1.3	0.0	0.0	3.0	2.3	2.7
Y071-14H50	x Y071-14	29	167	1.1	7.9	10.1	1.3	0.0	1.1	2.7	2.7	2.7
Y075-16H50	x Y075-16	29	166	5.7	14.9	16.1	1.7	0.0	0.0	4.3	4.3	4.3

TEST 403. EVALUATION OF HYBRIDS OF SELECTED PROGENY LINES FOR NONBOLTING, SALINAS, 2002-2003

(cont.)

Variety Description	Stand Count No.	Beets/ 100 No.	% Bolting 7/10	8/12	9/08	Emerg Score	Rhizoc Rot %	Downey Mildew %	Powdery Mildew 8/22	9/08	Mean
Hybrids from increase of FS progeny lines (cont.)											
R176-89-5H50 C790-15CMS x RZM R076-89-5	28	158	13.3	24.2	31.7	1.7	0.0	2.5	3.0	4.0	3.5
R176-89-5-4H50 C790-15CMS x R976-89-5-4	28	158	0.0	2.6	2.6	1.3	0.0	0.0	3.3	3.0	3.2
Mean	26.5	151.2	14.9	26.8	28.5	1.6	0.2	0.9	3.1	3.3	3.2
LSD (.05)	3.8	21.9	14.0	16.4	15.9	0.8	1.3	3.6	1.2	1.4	1.1
C.V. (%)	8.9	8.9	57.9	37.9	34.5	31.0	486.6	245.6	23.4	25.2	20.3
F value	5.6**	5.6**	6.4**	7.1**	7.4**	1.6*	1.3NS	1.0NS	3.7**	3.2**	3.8**

48 entries x 4 reps., sequential
1-row plots, 11 ft. long

Planted: April 30, 2003
Harvested: November 13, 2003

Variety	Description	Stand Count No.	Harvest Count No.	RZM DI	RZM Score %R(0-4)	Bolting Score	Leaf Pigment Score	Type of Plants Score
Checks								
US H11	susc. ck.	24.0	21.0	4.8	30.5	2	1	3
R039	Inc. R539, (C39R)	22.5	20.3	3.0	100.0	2	2	3
01-C37	susc. ck., Inc. U86-C37	23.3	20.0	4.2	54.8	2	2	3
R136	RZM-ER-% R936, (C79-8)	22.8	21.3	3.1	97.9	2	2	3
Y167	RZM-ER-% Y967, (C67/2)	21.8	20.3	3.2	95.0	2	2	3
Y275	RZM-% Y075	23.8	22.8	3.2	93.5	2	2	3
02-US22/3	Inc. 97-US 22/3	22.5	20.5	5.1	22.7	2	1	3
R221	RZM-% R021	23.5	21.3	3.3	90.0	2	2	3
Beta 4776R	2/12/03	24.8	23.8	3.1	100.0	2	2	3
Beta 6600	2/5/02	21.3	20.5	4.5	42.8	2	2	3
Roberta	3/25/03	23.5	17.5	5.1	18.4	2	1	3
Angelina	3/19/02	23.3	22.8	3.1	97.9	2	2	3
Dorotea	2/21/02	19.3	19.5	4.1	58.1	2	2	3
HM-E17	susc. ck., 3/21/02	23.5	19.5	5.0	24.1	2	1	3
Y291H5	0833-5HO x RZM Y191	21.0	20.5	3.1	97.7	2	2	3
P207/8H5	0833-5HO x P007/8	21.3	20.3	3.2	95.1	2	2	3
Beta vulgaris subsp. maritima								
1	PI 504187	18.5	18.0	3.0	94.4	1	3	5
3	PI 504191	17.5	18.0	3.2	90.9	1	4	5
4	PI 504203	20.8	18.0	3.9	65.8	1	2	5
5	PI 504212	14.5	15.5	3.0	98.2	1	3	5
6	PI 504215	15.8	17.0	3.0	98.9	1	3	5
7	PI 504217	12.8	12.0	3.2	92.1	1	3	5
8	PI 504218	11.8	12.3	3.3	96.2	1	4	5
9	PI 504222	16.3	17.3	2.8	95.9	1	4	5

TEST 6203. EVALUATIONS OF PLANT INTRODUCTIONS (PI's), SALINAS, CA, 2003

(cont.)

Variety	Description	Stand Count No.	Harvest Count No.	RZM DI	RZM Score %R(0-4)	Bolting Score	Leaf Pigment Score	Type of Plants Score
Beta vulgaris subsp. *maritima* (cont.)								
10	PI 504224	17.5	14.0	3.8	67.1	2	3	5
11	PI 504227	14.3	14.8	2.7	100.0	1	4	5
12	PI 504229	11.0	12.0	2.8	98.7	1	4	5
13	PI 504231	13.8	14.0	3.2	87.0	1	4	5
14	PI 504232	15.5	13.5	3.0	98.2	1	3	5
15	PI 504243	16.8	15.3	3.5	77.1	1	3	5
16	PI 504244	8.0	8.5	3.0	91.3	1	4	5
17	PI 504245	14.5	14.0	3.0	89.0	1	3	5
18	PI 504246	12.5	12.5	3.1	89.8	1	4	5
19	PI 504249	9.0	9.8	3.1	96.4	1	4	5
20	PI 504252	13.0	14.8	3.2	89.0	1	3	5
21	PI 504256	12.3	11.5	3.1	94.0	1	3	5
22	PI 504276	16.0	15.3	3.1	93.0	1	4	5
23	PI 504280	14.5	14.3	3.6	77.9	1	2	5
24	PI 504281	12.8	11.3	2.8	95.4	1	4	5
25	PI 504283	16.0	16.0	3.1	96.9	1	3	5
26	PI 518317	18.3	18.3	3.3	92.7	3	3	5
27	PI 518336	9.0	9.0	3.1	100.0	1	3	5
28	PI 518344	21.8	21.5	3.6	82.1	3	3	5
29	PI 518357	20.0	20.3	3.2	90.7	1	3	5
Beta vulgaris subsp. *vulgaris*								
30	19169, Ames 19169	17.0	16.3	4.6	33.3	2	1	3
2	296539, Buszczynski	21.0	20.3	4.3	47.4	2	1	3
Checks								
F1001	Accession from Fargo, 4/14/03	19.0	23.3	4.2	48.2	2	1	3
P230	PMR-RZM-NB P030-#(C)	20.3	20.5	3.4	86.7	2	2	3

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(cont.)

Variety Description	Stand Count No.	Harvest Count No.	RZM DI	RZM %R(0-4) Score	Bolting Score	Leaf Pigment Score	Type of Plants Score
Mean	17.8	17.1	3.5	80.7	1.6	2.6	4.2
LSD (.05)	3.5	5.8	0.5	15.5	0.4	0.3	0.0
C.V. (%)	14.2	24.5	9.4	13.7	17.9	7.4	0.0
F value	13.4**	3.7**	15.7**	19.0	14.1**	91.5**	4.0NS

NOTES:

DI = disease index, where individual plants scored on a scale of 0 to 9 where 9 = dead. %R = %resistant where classes 0-4 were considered resistant.

Bolting Tendency without cold induction where: 1 = Annual, bolted; 2 = biennial, not bolted; 3 = mixed for bolting.

Mature Leaf Pigmentation where: 1 = light green; 2 = normal green; 3 = green/red mix; 4 = red; 5 = chlorophyll mutant.

Type of Plants where: 1 = fodder beet; 2 = leaf, chard; 3 = sugar; 4 = table beet, red beet; 5 = wild.

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SUGAR BEET RESEARCH
USDA-ARS Sugarbeet Research Unit in Fort Collins, Colorado

2003 REPORT

Section B

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USDA-ARS-NPA Sugar Beet Research Unit's Mission Statement

Utilize distinctive site environmental and disease-free characteristics and specifically developed team expertise to: develop new knowledge and adapt biotechnologies to modify host-pathogen relations that affect disease resistance, pathogenesis, and epidemiology in sugar beet and other plant species pertinent to sugar beet cultivation; discover new information and techniques to identify and produce genotypes exhibiting superior disease and stress tolerance and agronomic qualities; and provide new knowledge that improves production efficiency and biochemical processing characteristics of sugar beet.

(Projects 420, 421, 440, 441, 443, 903, and 904)

CONTENTS

PUBLICATIONS

Cramer, R. A., Byrne, P. F., Brick, M. A., Panella, L., Wickliffe, E., and Schwartz, H. F. Characterization of *Fusarium oxysporum* isolates from common bean and sugar beet using pathogenicity assays and random-amplified polymorphic DNA markers. Journal of Phytopathology 151(6):352-360. 2003.

Gallian, J.J. and L.E. Hanson. The perfect stage of powdery mildew of sugar beets found in Idaho and Colorado. Plant Disease. 87:200. 2003.

Hanson, L.E. and L. Panella. *Beta* PIs from the USDA-ARS NPGS evaluated for resistance to *Cercospora beticola*, 2002. Biological and Cultural Tests for Control of Plant Diseases (online). 18:F015. DOI:10.1094/BC18. 2003.

Hanson, L.E., A.L. Hill, and L. Panella. Variable virulence and genetic diversity in *Fusarium oxysporum* from sugar beet. Proceedings of the 1st Joint IIRB-ASSBT Congress, San Antonio, TX. pg. 887. 2003.

Hanson, L.E. Biological control of damping-off in sugar beet seedlings with *Trichoderma* species. Proceedings of the 1st Joint IIRB-ASSBT Congress, San Antonio, TX. pp. 889-893. 2003.

Hanson, L.E., A.L. Hill, and L. Panella. Variability in *Fusarium* isolates affecting sugar beet or spinach. Phytopathology. 93:S33. 2003. (abstract)

Hanson, L.E. and C.R. Howell. Elicitors of plant defense responses from biological control strains of *Trichoderma virens*. Phytopathology. (accepted for publication September 5, 2003).

Hanson, Linda E. and Lee Panella. Disease control in sugar beet. International Sugar Journal. 105:60-69. 2003. (review article)

Hanson, L.E. and L. Panella. Evaluation of *Beta* PIs from the USDA-ARS NPGS for resistance to curly top virus, 2002. Biological and Cultural Tests for Control of Plant Diseases (online). 18:F016. DOI:10.1094/BC18. 2003.

Hanson, L.E. and L. Panella. Rhizoctonia root rot resistance of *Beta* PIs from the USDA-ARS NPGS, 2002. Biological and Cultural Tests for Control of Plant Diseases (online). 18:F014. DOI:10.1094/BC18. 2003. (poster)

Hanson, L.E., A.L. Hill, and L. Panella. Variability in *Fusarium oxysporum* pathogenic on sugar beet (*Beta vulgaris*). ICPP2003. 2:335. 2003.

Panella, L. and L.E. Hanson. Notice of Release of FC710 (4X) Tetraploid, Multigerm Sugar Beet Germplasm. USDA-ARS Germplasm Release. 2003

Panella, L. and L.E. Hanson. USDA-ARS sugar beet germplasm developed in Fort Collins, CO evaluated for *Rhizoctonia* resistance, 2002. Biological and Cultural Tests for Control of Plant Diseases (online). 18:F013. DOI:10.1094/BC18. 2003.

Panella, L. and L. Frese. Beta germplasm evaluation data in two databases, GRIN & IDBB. Proceedings from the 1st joint International Institute of Beet Research-American Society of Sugar Beet Technologists Congress, 26th Feb.-1st March, 2003. pp. 233-241. 2003.

Panella, L. and L.E. Hanson. USDA-ARS sugar beet germplasm developed in Fort Collins, CO, evaluated for Rhizoctonia resistance, 2002. Biological and Cultural Tests for Control of Plant Diseases. (online) 18:F013. DOI:10.1094/BC18. 2003.

Panella, L., R. Hannan, and A. Hodgdon. *Beta* genetic resources: North American activities. *in*: Frese, L., C. Germeier, E. Lipman and L. Maggioni, compilers. Report of a Working Group on *Beta* and World *Beta* Network. Second joint meeting, 23-26 October 2002, Bologna, Italy. IPGRI, Rome, Italy. Accepted 3/30/2003 [2004].

Panella, L. and R. T. Lewellen. Notice of Release of FC201 Monogerm, O-type Sugarbeet Germplasm with Resistance to Rhizomania and Other Diseases. USDA-ARS Germplasm Release. 2003.

Panella, L. and R. T. Lewellen. Notice of Release of FC301 Monogerm, O-type Sugarbeet Germplasm with Resistance to Rhizomania and Cercospora Leaf Spot. USDA-ARS Germplasm Release. 2003.

Panella, L. Forty years of breeding sugar beet for resistance to *Rhizoctonia solani* – where are we? Agr. Abstr. p. Western Society of Crop Science Meeting, 22 - 24 June, Fort Collins, CO) 2003. (poster)

Panella, L., L. E. Hanson, and M. West. Evaluation of Disease Resistance in a Field Nursery. Agr. Abstr. p. (ASA-CSSA-SSSA Annual Meeting, 2 - 6 Nov, Denver, CO) 2003. (poster).

Richards, C. M., M. Brownson, S. E. Mitchell, S. Kresovich, and L. Panella. Polymorphic microsatellite markers for inferring diversity in wild and domesticated sugar beet (*Beta vulgaris*). Mol Ecol Notes Accepted 12-19-03.

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NOTICE OF RELEASE OF FC710 (4X) TETRAPLOID, MULTIGERM SUGAR BEET GERMPLASM

The Agricultural Research Service, United States Department of Agriculture, in cooperation with the Beet Sugar Development Foundation, announces the release of FC710 (4X) tetraploid, multigerm sugar beet germplasm. This line was developed in the breeding program of L. Panella, and L. E. Hanson, Sugarbeet Research Unit, USDA-ARS, Fort Collins, Colorado. This line has excellent resistance to root-rotting strains (AG-2-2) of *Rhizoctonia solani* Kühn. It is also resistant to leaf spot caused by *Cercospora beticola* Sacc. It is released as a tetraploid pollinator, or population from which to select tetraploid pollinators with resistance to rhizoctonia root rot and cercospora leaf spot.

FC710 (4X) is released from seed production 20001022 and has also been tested as 971017. FC710 (4X) (PI 633733) is tetraploid ($2n = 4x = 36$), multigerm (*MM*), non-O-type, pseudo-self-fertile, and has 29% green hypocotyls (93 plants counted). It is a colchicine doubled version of FC710, which was registered in 1991 and FC710 (4X) performs comparably to FC710. FC 710 was developed through two cycles of recurrent selection, with progeny tests for rhizoctonia root rot resistance and sucrose yield, and nine cycles of mass selection for rhizoctonia root rot. It is 42% from C817 (synthetic from GW 359), 28% from breeding lines resistant to cercospora leaf spot and black root (caused by *Aphanomyces cochlioides* Drechs.) and 30% from reciprocal hybrids between elite sugarbeet breeding lines and *Beta vulgaris* subspecies *maritima* accessions (i.e., approximately 15% *Beta vulgaris* ssp. *maritima* germplasm). Ninety-one colchicine treated seedlings with thickened or distorted hypocotyls were selected, transplanted, vernalized, and induced to flower. Pollen from approximately 100 plants was sized to determine ploidy and seed was harvested individually (mother roots) from 34 tetraploid C_0 plants. Five seeds of each mother plant were planted, vernalized, and induced to flower. Again, pollen was sized to confirm ploidy and 75 tetraploid plants from 28 of the original C_0 mother roots harvested for seed to produce the C_1. The C_1 seed was planted in the greenhouse and pollen sized to confirm ploidy level. The C_2 seed was harvested from 48 tetraploid plants. C_2 seed went through another cycle of seed production and pollen sizing in the greenhouse, 100 plants were grown and 91 plants harvested to produce C_3 seed. This seed was tested in artificially created epiphytotics of rhizoctonia root rot and cercospora leaf spot, bulk increased in a field isolation plot in 1997 (180 plants) and again in 2000 (182 plants). The increased seed was tested from 1998 through 2002.

FC710 (4X) exhibited excellent resistance to rhizoctonia root rot when tested under strong disease pressure. FC710 (4X) performance was equal or superior to rhizoctonia-resistant checks in disease index (DI) ratings in 2000 and 2002 (DI of 0 = no root rot and 7 = all plants dead). FC710 (4X) performed significantly better than the susceptible check (FC901/C817). FC710 (4X) had mean DIs of 3.6 and 2.4 (2000 and 2002), whereas the highly resistant check (FC705/1) had DIs of 3.1 and 1.7,

respectively. Percentages of resistant plants (those rated 0 or 1) were 0 and 31 for FC710 (4X); and 13 and 58 for the highly resistant check.

FC710 (4X) also exhibited good resistance to cercospora leaf spot when tested in an artificial epiphytotic. In tests from 1999 and 2000, it was significantly better than the susceptible control and not significantly different from the resistant control. The following DI ratings (DI of 0 = no leaf spot and 10 = all plants dead) represent the most severe rating (last of three or four ratings each season). In 1999 and 2000, DIs of FC710 (4X) were 3.3 and 2.7; DIs of the resistant control (FC504CMS/FC502-2//SP6322-0) were 2.7 and 2.3; DIs of the susceptible control (SP351069-0) were 6.3 and 3.7, respectively. FC710 (4X) does not show tolerance to the curly top virus and has never been tested against black root.

In 2002, FC710 (4X) was yield tested for agronomic quality. One-row plots, replicated six times were planted at the USDA-ARS Crops Research Lab-Fort Collins Research Farm, CO, on May 3rd. Plots were 3.04 m long with 56 cm between rows and 20 to 25 cm within-row spacing. Roots were harvested on October 8th and sent to the tare lab of Western Sugar Co. (in Scotts Bluff, NE) for analyses. The average value of three commercial varieties - Beta 6045, HM1955, Monohikari - was used as a standard for comparison. In percent sucrose, FC710 (4X) was 92.2% of the standard, and in sugar loss to molasses, FC710 (4X) was 118.2% of the standard.

Breeder seed of FC710 (4X) is maintained by USDA-ARS and will be provided in quantities sufficient for reproduction upon written request to Lee Panella (lpanella@lamar.colostate.edu), Sugar Beet Research, USDA-ARS, Crops Research Laboratory, 1701 Center Ave., Fort Collins, CO 80526-2083. Genetic material of this release has been deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new varieties/cultivars. We request that appropriate recognition be made of the source when this germplasm contributes to a new cultivar. U.S. plant variety protection will not be requested for FC710 (4X).

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NOTICE OF RELEASE OF FC201 MONOGERM, O-TYPE SUGARBEET GERMPLASM WITH RESISTANCE TO RHIZOMANIA AND OTHER DISEASES

The USDA Agricultural Research Service (ARS), in cooperation with the Beet Sugar Development Foundation (BSDF), announces the release of FC201 sugarbeet germplasm. This germplasm was developed in the breeding programs of Drs. L. Panella and R. T. Lewellen, USDA-ARS, Fort Collins, Colorado, and Salinas, California. FC201 is a segregating population with a high frequency of the *Rz* allele conferring resistance to rhizomania caused by *Beet necrotic yellow vein virus*. It is segregating for resistance to root-rotting strains (AG-2-2) of *Rhizoctonia solani* Kühn and to the sugar beet root aphid (*Pamphigus* sp.), has moderate resistance to cercospora leaf spot caused by *Cercospora beticola* Sacc., to black root caused by *Aphanomyces cochlioides* Drechsl., and the *Beet curly top virus*. FC201 is a heterogeneous population from which to select disease resistant monogerm, O-type parents to infuse multiple disease resistance on the female side of hybrids. There is no CMS equivalent. FC201 is released from Salinas seed production 01-FC1014 and has been tested as 00-FC1014 and 01-FC1014.

FC201 is an O-type germplasm segregating for hypocotyl color(R) and for monogerm (*mm*). It is the F_4 of the cross ' C890'*aa* x ' FC708' (23 F_1 plants) bulked with the cross ' C859'*aa* x ' FC708' (18 F_1 plants). Seed from both F_1 populations was combined for bulk increase of the F_2 after germination testing to make the parental contribution 25% from C890, 25% C859, and 50% FC708. The F_2 seed was planted in Salinas and selected for rhizomania resistance, agronomic performance, and percent sucrose. The F_3 population was a bulk increase of 25 plants selected from 600 grown in the field under severe rhizomania conditions and increased in the greenhouse. Seed from the F_3 was sent to Oregon for steckling production, and the F_4 was an increase at Salinas without selection of about 250 stecklings; seed from only male-sterile plants was harvested. Half-sib family grow-outs indicated that the male-sterility was genetic male-sterility (*aa*) and genetic-cytoplasmic male-sterility (CMS). Progeny testing could be used to identify and separate genetic-male sterility from CMS and to produce a near equivalent CMS counterpart to the male fertile, O-type.

When tested at Fort Collins, CO, in 2003 for resistance to rhizoctonia root rot under strong disease pressure, the FC201 population was not significantly different from the susceptible check, but individual roots were scored as resistant, i.e. DI < 3 (DI of 0 = no root rot and 7 = all plants dead). In a greenhouse test for resistance to sugarbeet root aphid at Shakopee, MN, in 2003, again, although the population was not different from the susceptible control, there were a number of roots which were scored as 1 (1 = free from aphids to 4 = heavily infested with aphids).

When tested in Fort Collins, CO, and Rosemount, MN, in 2002 and 2003 for resistance to cercospora leaf spot, the scores were intermediate (significantly more resistant than the susceptible check and significantly less resistant than the resistant check). The same intermediate resistance was seen when tested at Shakopee, MN, in 2002 and 2003 for resistance to Aphanomyces root rot. In the BSDF curly top nursery at Kimberly, ID, in 2003 FC201 had a DI of 5.0 over three replications (not statistically analyzed) compared to 'US H11' with a DI of 3.3 and 'Monohikari' with a DI of 7.0 (1 = no damage to 9 = plant dead). When FC201 was tested for O-type, restorer genes were present only at a very low frequency.

In observation and evaluation tests at Salinas in 2002 and 2003, FC201 was moderately susceptible to powdery mildew caused by *Erysiphe polygoni* DC; intermediate in reaction to Erwinia root rot caused by *E. carotavora betavascularum* Thomsen et al. with 60 - 70% resistant plants; and moderately susceptible to intermediate for bolting tendency in fall plantings. Sucrose concentration was intermediate to a group of monogerm populations and inbred lines. The canopy of FC201 is dark green with leaf shape similar to FC708.

Breeder seed of FC201 is maintained by USDA-ARS and will be provided in quantities sufficient for reproduction upon written request to Sugarbeet Research, USDA-ARS, Crops Research Laboratory, 1701 Center Ave., Fort Collins, CO 80526-2083. Genetic material of this release will be deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new varieties/cultivars. We request that appropriate recognition be made of the source when this germplasm contributes to a new cultivar. U.S. plant variety protection will not be requested for FC201.

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NOTICE OF RELEASE OF FC301 MONOGERM, O-TYPE SUGARBEET GERMPLASM WITH RESISTANCE TO RHIZOMANIA AND CERCOSPORA LEAF SPOT

The USDA Agricultural Research Service (ARS), in cooperation with the Beet Sugar Development Foundation (BSDF), announces the release of FC301 sugarbeet germplasm. This germplasm was developed in the breeding programs of Drs. L. Panella and R. T. Lewellen, USDA-ARS, Fort Collins, Colorado, and Salinas, California. FC301 is a germplasm with a moderate frequency of the Rz allele conferring resistance to rhizomania caused by *Beet necrotic yellow vein virus*. It has been selected for resistance to cercospora leaf spot caused by *Cercospora beticola* Sacc., and has moderate resistance to black root caused by *Aphanomyces cochlioides* Drechsl., and the *Beet curly top virus* (BCTV). FC301 is a population from which to select disease resistant, monogerm, O-type parents to infuse multiple disease resistance on the female side of hybrids. There is no CMS equivalent. FC301 is released from Salinas seed production 01-FC123, and has been tested as 00-FC123 and 01-FC123.

FC301 is an O-type germplasm segregating for hypocotyl color (94% R-) and for monogerm (90% mm). Two crosses were made. The first cross was 'C890'aa x two pollen donors – 'FC607' and 'FC604' (approximately 50 F_1 plants) – bulked with the cross 'C859'aa x the same two pollen donors (approximately 50 F_1 plants). Seed from both F_1 populations was combined for bulk increase of the F_2 after germination testing to make the parental contribution equal from both female parents. The F_2 seed was planted in Fort Collins and 90 mother roots were harvested and selfed. Seventy-five selfed families were produced and planted in the cercospora leaf spot nursery in Fort Collins, and in the BCTV nursery in Kimberly, ID. Based on performance in these nurseries, three populations were developed – two containing the best five families for leaf spot resistance and BCTV resistance and one population containing the five families that had the best performance in both nurseries. Mother roots were dug from the Fort Collins cercospora leaf spot nursery and seed was produced in the greenhouse.

These three populations were sent to Salinas, where, combined, selections were made for rhizomania resistance; resistance to Erwinia root rot caused by *E. carotovora betavasculorum* Thomsen et al.; powdery mildew caused by *Erysiphe polygoni* DC, agronomic performance; and percent sucrose. The selected roots from these three populations were inter-pollinated, and monogerm and multigerm seed was separated, forming two populations – 99-1,2,3 M and 99-1,2,3 m. Seed from the monogerm population was either sent to Oregon for steckling production or planted in the Salinas rhizomania nursery. Stecklings were obtained from Oregon in June, 2002, and male-fertile, high quality monogerm plants were selected near anthesis and individually selfed to produce S_1 progeny, while being crossed simultaneously to an annual male-sterile tester. The F_1 hybrids were indexed for O-type in December, 2000, and found to be uniformly male-sterile, suggesting that fertility restorer genes were present at only a low frequency, and O-type selection was unnecessary. Seed of the

population and the S_1 progenies was planted the Oregon steckling nursery and the Salinas rhizomania nursery in August, 2000. From the Salinas rhizomania nursery, S_1 plants from within S_1 progenies and plants from the population were selected for resistance to rhizomania. Concurrently, during this time, seed from the original Fort Collins population, which had been selected strictly for leaf spot resistance and then re-selected for leaf spot resistance using the leaf disc method, was planted also in the Salinas rhizomania nursery and Oregon steckling nursery. In March 2001, induced, selected plants from Salinas and stecklings from Oregon were pooled and recombined through the male-sterile plants from all three phases. There was nearly equal representation from the new Fort Collins cercospora leaf spot population, the S_1 lines, and the population selected for resistance to rhizomania. Seed from the male-sterile plants was harvested separately and the composite called 01-FC123. 01-FC123 seed was released as FC301. Half-sib family grow outs indicated that the male-sterility was mixed genetic male-sterility (*aa*) and genetic-cytoplasmic male-sterility (CMS). Progeny testing could be used to identify and separate genetic sterility from CMS, and to isolate a near equivalent CMS counterpart to the male-fertile, O-type.

In a greenhouse test for resistance to sugar beet root aphid (*Pemphigus* sp.) at Shakopee, MN, in 2003, the population was not different from the susceptible control although there were a number of roots which were scored as 1 (1 = free from aphids to 4 = heavily infested with aphids). When tested in Fort Collins, CO, and Rosemount, MN, in 2002 and 2003 for resistance to cercospora leaf spot in an artificial epiphytotic, the scores were either intermediate (significantly more resistant than the susceptible check and significantly less resistant than the resistant check) or not significantly different from the resistant check. The same level of resistance was seen when tested at Shakopee, MN, in 2003 for resistance to Aphanomyces root rot. In the BSDF curly top nursery at Kimberly, ID, in 2003 FC301 had a DI of 4.3 over three replications (not statistically analyzed) compared to US H11 with a DI of 3.3 and Monohikari with a DI of 7.0 (1 = no damage to 9 = plant dead). When tested at Fort Collins, CO, in 2003 for resistance to rhizoctonia root rot under strong disease pressure the FC301 population was not significantly different from the susceptible check.

In observation and evaluation tests at Salinas in 2002 and 2003, FC301 was moderately susceptible to powdery mildew; intermediate in reaction to Erwinia root rot with 50 – 65% resistant plants; and moderately resistant to intermediate for bolting tendency in fall plantings. Sucrose concentration was moderately low in comparison to a group of monogerm populations and inbred lines.

Breeder seed of FC301 is maintained by USDA-ARS and will be provided in quantities sufficient for reproduction upon written request to Sugarbeet Research, USDA-ARS, Crops Research Laboratory, 1701 Center Ave., Fort Collins, CO 80526-2083. Genetic material of this release will be deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new varieties/cultivars. We request that appropriate recognition be made of the source when this germplasm contributes to a new cultivar. U.S. plant variety protection will not be requested for FC301.

BSDF Project 903 – Evaluation of Contributed Lines for Resistance to *Rhizoctonia solani*, a Causal Fungus of Sugar Beet Root Rot.

L.E. Hanson and L. Panella

Annually, for over thirty years, the sugar beet breeding program in Fort Collins has included the production of an artificial epiphytotic through inoculation with *Rhizoctonia solani* to evaluate and select for resistance to root rot caused by this pathogen. We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF.

In 2003 the project involved field studies conducted at the Crops Research Lab-Fort Collins Research Farm near Wellington, CO. Randomized, complete-block designs with five replicates were used to evaluate ARS breeding germplasm and Plant Introduction accessions. *Rhizoctonia*-resistant line FC703, highly resistant FC705-1, and susceptible FC901/C817 were included as internal controls.

One-row plots, planted May 15th, were 14 feet long with 22 inches between rows and 8 to 10 inches within-row spacing. The field was sprayed twice with Betamix Progress, Upbeet, and Stinger (June 19 and 26) to control weeds. The field was thinned by hand and irrigated as necessary. Inoculation with dry, ground, barley-grain inoculum of *Rhizoctonia solani* AG-2-2 isolate R-9 was performed on July 10th; immediately after inoculation, a cultivation was performed so as to throw soil into the beet crowns. Beets were harvested August 27 through September 2. Each root was rated for rot on a scale of 0 to 7 (dead) as previously described. ANOVAs were performed on disease indices (DIs), percent healthy roots (classes 0 and 1 combined), and percentage of roots in classes 0 thru 3. Percentages were transformed to arcsin-square roots to normalize the data for analyses. LSDs are provided for comparing entries with those of our internal checks.

The high daytime temperatures in the summer of 2003 (Figure 1), combined with a moderate inoculum load, contributed to a severe root rot epidemic. Severe disease developed by late August. Mean DIs across all tests for highly resistant FC705-1, resistant FC703, and susceptible FC901/C817 controls were 3.2, 3.3, and 5.5 respectively. Mean DIs for these controls in 2002 were 1.8, 2.1 and 4.3 respectively. Percentages of healthy roots were 12.2, 8.7, and 1.4% for these controls. Percentages of roots in disease classes zero thru three were 57.4, 50.5, and 7.0, respectively. The highest and lowest DIs for the evaluated lines were 6.9 and 2.9, respectively.

2003 Weather
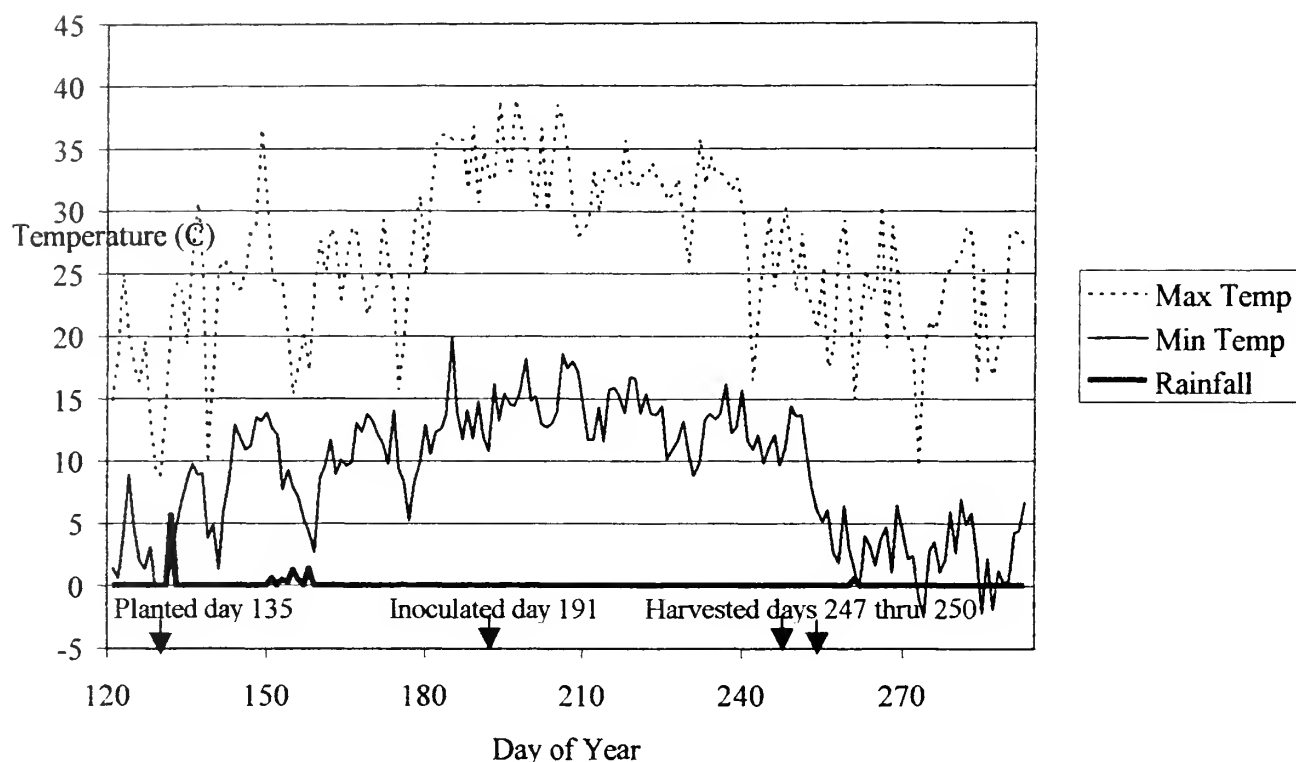
Figure 1. Summary of the weather data for 2003 Rhizoctonia root rot nursery.

The experiment mean, the mean of the susceptible check, the mean of the resistant check, and the mean of the highly resistant check are given for each of the experiments in the nursery. LSD is at the t=0.05 level.

Table 1. Summary data of the 2003 Rhizoctonia root rot nursery

Exp	Disease Index					Percent Healthy (classes 0&1)					Percent in Classes 0 to 3				
	Mean	Sus.	Res	H. res.	LSD	Mean	Sus.	Res.	H. res.	LSD	Mean	Sus.	Res.	H. res.	LSD
1R	5.5	5.8	3.8	2.9	0.5	1.7	0.0	8.2	23.0	4.8	6.4	0.0	35.2	59.2	9.2
2R	5.4	5.0	3.0	3.0	1.0	2.3	0.0	13.8	9.6	9.5	19.6	13.0	67.4	71.4	18.9
3R	5.0	5.6	3.7	3.8	0.6	0.5	0.0	2.8	2.0	ns	10.5	2.0	37.6	41.4	13.9
4R	5.1	5.2	3.5	3.5	1.2	3.6	2.8	20.2	11.6	ns	12.8	9.6	40.0	42.9	20.3
5R	4.0	5.1	3.2	3.2	0.9	11.6	9.2	17.2	19.4	13.7	37.3	18.6	56.0	54.8	20.6
7R	4.5	5.3	3.4	3.6	0.7	0.5	0.0	0.0	3.4	ns	1.0	11.0	48.2	51.0	15.9
8R	4.9	5.7	3.0	2.9	0.8	5.7	7.2	18.6	23.0	11.2	21.2	9.2	64.2	66.2	14.5
9R	4.4	5.1	3.5	2.9	0.8	5.4	1.4	16.0	18.0	ns	25.2	11.8	49.4	69.8	19.0

Percent in Classes is the transformed value (arcsin-square root)
Mean = Experiment Mean;
Sus. = Susceptible Check (FC901/C817);
Res. = Resistant Check (FC703);
H res. = Highly Resistant Check (FC705/1)
ns = not statistically significant

BSDF Project 904 – Evaluation of Contributed Lines for Resistance to *Cercospora beticola*, Causal Fungus of Cercospora Leaf Spot.

L.E. Hanson and L. Panella

The breeding program in Fort Collins has created an annual artificial epiphytotic through inoculation with *Cercospora beticola* for over forty years. This epiphytotic has been used to evaluate and select for resistance to leaf spot caused by *C. beticola*. We have been pleased to participate in and lead this cooperative research project between the ARS, Colorado State University, and the BSDF.

In 2003 the field plots were grown at the Irrigation Research Center near Yuma, CO. Randomized complete-block designs, with three replications, were used to evaluate commercial and experimental entries. Internal controls included a highly susceptible synthetic (SP351069-0) and a resistant check (FC504CMS/FC502-2//SP6322-0). Two-row plots were 12 feet long, with 22-inch row spacing and an 8- to 10-inch within-row plant spacing. The trial was planted on May 6. Inoculations were performed on July 16 and July 23. Evaluations were made on August 29, September 5, 12, and 19, with the peak of the epidemic occurring between the second and third date. The field was sprayed twice with Betamix Progress, Upbeet, and Stinger (June 12 and 23) to control weeds. The field was irrigated as necessary.

The high temperatures in the summer of 2003 and low moisture (Figure 2) contributed to a moderate leaf spot epidemic, which did not become severe enough to rate until the end of August. Disease severity increased through the first two weeks of September. By the third rating (September 12), means of the resistant and susceptible internal control were 3.5 and 5.8 (scale of 0-10), respectively across the nursery. In 2002 (September 25), these means were 3.8 and 4.5, respectively. Means of contributor lines in 2003 ranged from 3.0 to 7.3. Table 2 shows the data for the nursery from the three ratings in September.

Table 2. Summary data of the 2003 Cercospora leaf spot disease nursery.

The experiment mean, the mean of the susceptible check, and the mean of the resistant check are given for each of the experiments in the nursery, for each evaluation date.

Exp.	September 5th Disease Index				September 12th Disease Index				September 19th Disease Index			
	Mean	Sus.[1]	Res.[2]	LSD	Mean	Sus.	Res.	LSD	Mean	Sus.	Res.	LSD
1A	4.6	5.3	2.7	1.09	4.5	5.0	3.0	1.02	4.2	4.3	2.7	0.89
3A	4.7	8.0	4.0	0.88	4.7	7.3	4.0	1.02	4.2	6.7	3.3	0.80
4A	3.9	5.0	2.7	0.85	4.1	5.0	3.3	0.76	4.3	5.0	3.0	0.66
5A	3.9	6.3	3.0	1.01	3.7	5.7	3.0	0.93	3.8	5.0	2.7	0.73
Mean	4.28	6.15	3.10		4.25	5.75	3.33		4.13	5.25	2.93	

[1]Cercospora Susceptible Check - SP351069-0
[2]Cercospora Resistant Check - FC 504CMS/FC 502-2//SP6322-0

2003 Weather
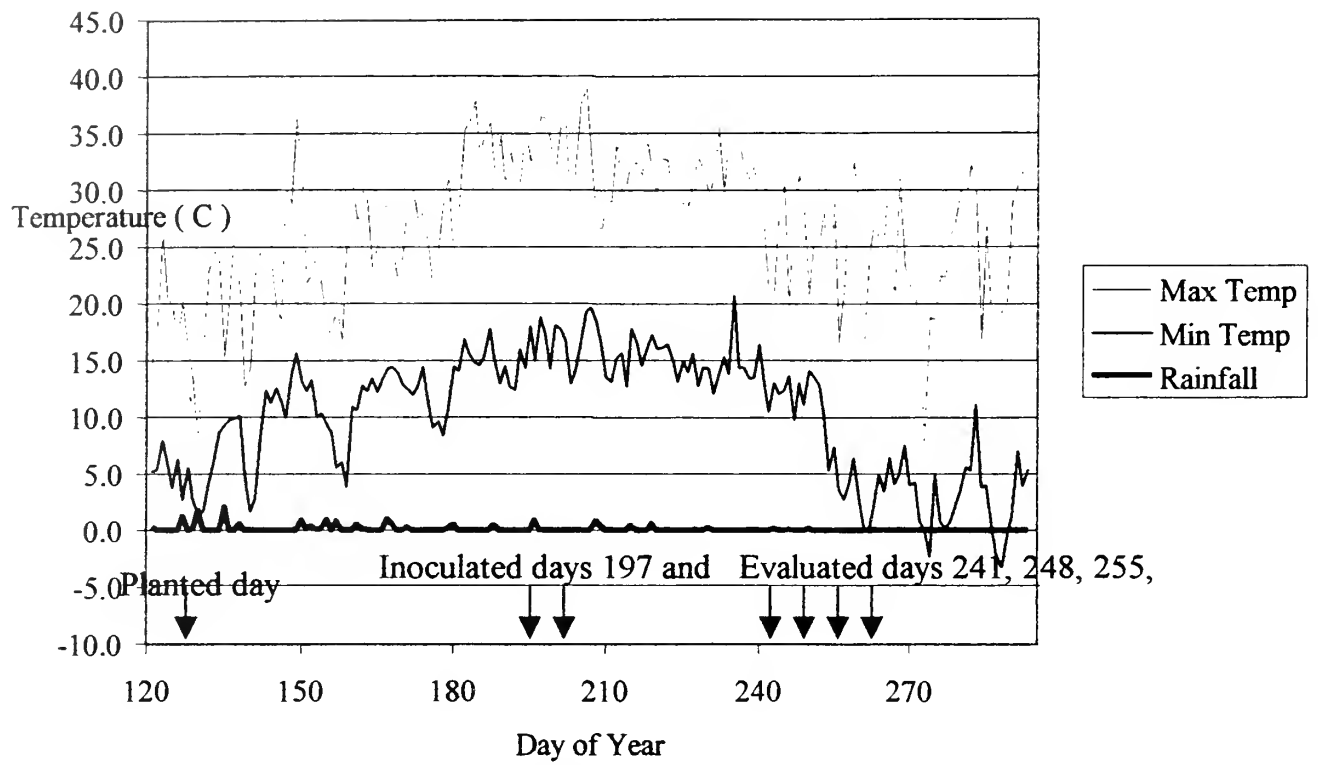
Figure 2. Summary the 2003 weather data for Cercospora Leaf Spot Nursery.

BSDF Project 420 – Screening Biological Control Agents for *Rhizoctonia solani* Control on Sugar Beets.

L.E. Hanson, L. Panella, A.L. Hill, G.M. Preston

Rhizoctonia root and crown rot (caused by the fungus *Rhizoctonia solani* Kühn) is the most common and most serious fungal root disease of sugar beet in the United States. The disease is endemic in beet producing areas of the United States. *Rhizoctonia solani* also causes a damping-off in sugar beet seedlings. If the infection is light, the fungus may cause crown rot or dry rot canker on maturing roots later in the season. Thus control of this fungus in the seedling stage might offer some reduction in disease later in the season, as well as improving crop stands.

Biological control can provide an alternative to chemical pesticides which are the subject of increasing regulation and restrictions due to environmental and public health concerns. Biological control is compatible with host genetic resistance and thus can be used in an IPM program. While resistance to *R. solani* is available, it does not provide complete immunity, and resistance is not well expressed in seedlings, thus the addition of other control methods is desirable.

In 2003, four *Pseudomonas fluorescens* strains (PMS382, F113, SBW25, and ΔWSP) from G. M. Preston were used. All four strains showed biological control activity against *Pythium ultimum* in Dr. Preston's work. *Trichoderma virens* strains included two strains (G-6 and G-4) from Texas cotton field soil with activity against damping-off in cotton, two UV-mutants of strain G-6, one (AB1-5) with biological control activity on cotton and one (AB1-4) without biological control activity, and isolates obtained from sugar beet, LH-2, SB-1, T-2, T-3, T-4, and T-33. In addition, two *T. koningii* strains (Tk-7 and TkG-12), one *T. longibrachiatum* and one *T. atroviride* strain were used in tests. Additional strains from sugar beet are being obtained and will be included in future tests.

In *in vitro* antibiosis tests against *R. solani*, all four bacterial isolates inhibited *R. solani* growth on potato dextrose agar (PDA). In tests with *Trichoderma*, isolate PMS382 inhibited the growth of all strains of *Trichoderma* tested. The three other *P. fluorescens* strains did not significantly inhibit growth of any of the *T. virens* strains, indicating that these bacterial and fungal strains may be used in combination. Growth of *T. atroviride, T. longibrachiatum* and *T. koningii* was inhibited by F113, but not by SBW25 or ΔWSP. None of the *Pseudomonas* strains were significantly inhibited by any of the fungal strains. When seed was soaked in a *Pseudomonas* suspension (F113 or SBW25), air dried, treated with *Trichoderma*, and grown in wheat bran+peat moss; both *Pseudomonas* and *Trichoderma* could be isolated from the seed.

In antibiosis tests against *R. solani, T. virens* strains G-6, T-2, T-3, T-4 T-33 and SB-1 inhibited *R. solani*, while G-4, AB1-5, LH-2 and AB1-4 showed no inhibitory activity. Strain G-6 is a "q" strain of *T. virens* that produces the antibiotic gliotoxin, which has activity against *R. solani*. Strain G-4 is a "p" stain of *T. virens* that produces the antibiotic gliovirin, which has activity against *Pythium ultimum*, but not against *R. solani*. Our results suggest that T-2, T-3, T-4, T-33, and SB-1, which we isolated from sugar beet, are "q" strains and LH-2 is a "p" strain. The *T. atroviride, T. longibrachiatum,* and *T. koningii* strain Tk-7 did not inhibit *R. solani in vitro*, although *T. koningii* strain TkG12 showed weak inhibition of *R. solani* AG-4 with little effect on AG-2-2.

In greenhouse biological control assays, no significant disease control was observed with any of the *Pseudomonas* isolates. Seed treatment with wheat bran+peat moss preparations of G-6, LH-2, and AB1-5 significantly increased seedling survival in all tests. Seed treatment with SB-1 and G-4 each showed significantly increased seedling survival in more than half of all tests, but survival was lower than with G-6 and results were more variable. T-2, T-3, T-4, and T-33 each showed activity in two or more tests, but survival was variable. No significant increase in survival was observed with

AB1-4 in any tests. All of the *T. virens* strains colonized the root system well. No significant disease control was observed for the *T. atroviride*, *T. longibrachiatum*, or *T. koningii* strains.

Table 3. Survival of sugar beet (FC403) seedlings with and without *R. solani* (AG-2-2) treated with a wheat bran + peat moss preparation of *T. virens* strain G-6 or with the wheat bran + peat moss carrier alone.

Treatment	Percent survival, field[1]
Carrier control[2]	54 a[3]
Fungicide[4]	57 a
T-3	29 c
T-4	49 ab
T-33	49 ab
LH-2	40 bc
SB-1	35 c
AB1-4	37 c
R. solani (R9)	3 e
Fungicide[4] + *R. solani*	3 e
T-3 + *R. solani*	9 de
T-4 + *R. solani*	11 de
T-33 + *R. solani*	17 d
LH-2 + *R. solani*	9 de
SB-1 + *R. solani*	11 de
AB1-4 + *R. solani*	4 e

[1] Average percent seedling survival from six replicates 21 days after planting under field conditions.
[2] Carrier control is wheat bran and peat moss.
[3] Percentages in the same column followed by the same letter are not significantly different by Fischer's LSD ($\alpha=0.05$).
[4] Fungicide seed treatment was Apron (metalaxyl) and Thiram (tetramethylthiuram disulfide).

In field tests for biological control activity with a subset of isolates, seed treatment with wheat bran+peat moss preparations of T-33 significantly increased seedling survival under very heavy *R. solani* pressure (Table 3). No significant increase was detected for any other isolates. Differences between activity in greenhouse and field tests are not unusual with biological control agents. For example, isolate G-6 was from acid soil and is reported to provide control in acid soils, but little or no control in alkaline soils. The soil in this field was approximately pH 7.6. Isolate SB-1, which gave

significantly increased control in the field in 2002, did not provide significant disease control in 2003 at a 95% probability, however, SB-1 and T-4 gave significantly higher survival than the untreated or fungicide controls at a 90% probability and might prove more effective at a lower disease pressure. At the level of infestation in this trial, a fungicide seed treatment of Apron+Thiram did not give any detectable disease control compared to bare seed.

No growth promotion of sugar beet was detected for any of the *Trichoderma* isolates on seedlings. There were no significant differences in the timing of seed germination, seedling height, seedling fresh weight or root weight between control plants and those treated with *Trichoderma* at two or three weeks after planting in the absence of *Rhizoctonia solani*. No significant growth promotion was observed for any of the *Pseudomonas* isolates either for any of these parameters.

Mycoparasitic ability was tested by plating potential biocontrol agents and sugar beet pathogens on a low nutrient medium and examining the area of interaction. In some cases, interaction was not observed because growth of the pathogen was inhibited by the *Trichoderma* and only dead hyphae of the pathogen were found in the area of *Trichoderma* growth. However, when interaction occurred, hyphal coiling (Fig. 3) was observed, and hyphal penetration was detected for all strains of *T. virens* except AB1-4 and AB1-5. These two isolates previously had been demonstrated to show no mycoparasitism *in vitro*.

Figure 3. Hyphal coiling of *Trichoderma* around *Rhizoctonia solani*. Hyphal coiling is associated with mycoparasitism in *Trichoderma*. Arrow indicates *Trichoderma* mycelium
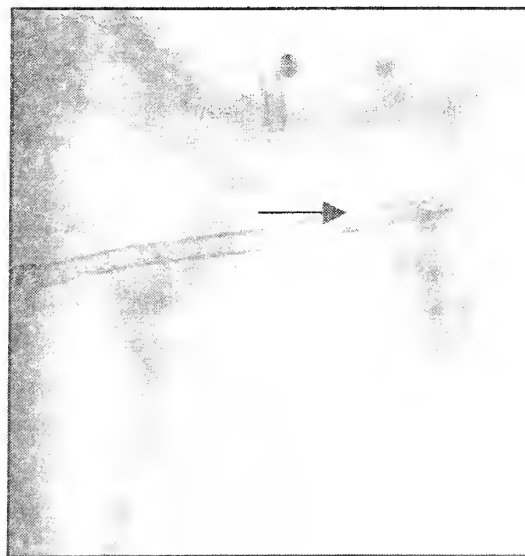
BSDF Project 421 – Variability in *Fusarium oxysporum* from Sugar Beets in the United States.

L.E. Hanson, L. Panella, A.L. Hill

Fusarium yellows causes significant reduction in root yield, sucrose percentage and juice purity in affected sugar beets. Research in our laboratory and others on variability in *Fusarium oxysporum* associated with sugar beets demonstrated that isolates that are pathogenic on sugar beet can be highly variable. A better understanding of this variability is important in the efforts to test for Fusarium yellows resistance in beets and efforts to breed for resistance.

In 2002, 114 *Fusarium* isolates were obtained from sugar beets and in 2002-2003 these were identified to species. Isolates included 60 *F. oxysporum*, 19 *F. solani*, 16 *F. equiseti*, 8 *F. avenaceum*, 7 *F. acuminatum*, and one isolate each of *F. prolilferatum*, *F. scirpi*, *F. subglutinans*, and *F. verticillioides*. *Fusarium subglutinans* has been reported from stored sugar beet, but not from actively growing beets. We have not found any previous references to *F. scirpi* in sugar beet. Pathogenicity tests on sugar beet were started for these isolates in 2003.

In 2003, 129 isolates of *Fusarium* were obtained from sugar beet and identified to species. Isolates included 75 *F. oxysporum*, 16 *F. equiseti*, 13 *F. solani*, 6 *F. culmorum*, 5 *F. acuminatum*, 3 *F. proliferatum*, two isolates each of *F. avenaceum*, *F. crookwellense*, *F. semitectum*, *F. subglutinans*, and *F. verticillioides*. In addition, one isolate of *F. graminearum* was identified. *Fusarium culmorum* has been reported to cause a root rot of sugar beet under drought conditions in Europe, and there were drought conditions in some areas in 2003. We did receive some root rot samples in 2003, from which *Fusarium* were obtained. *Fusarium solani* was isolated from both sugar beet and dry bean from two fields with root rot. *Fusarium solani* has been reported to cause a root rot in sugar beet, and dry or root rot of dry bean. The causal agent for dry root rot of bean is reported to be *Fusarium solani* f.sp. *phaseoli*, with some host specificity for bean. Because these root rot samples were from the same field it needs to be determined whether the same isolates could affect both bean and beet. *Fusarium graminearum* has been associated with sugar beet in Europe, and has been isolated from beets in storage. *Fusarium crookwellense* and *Fusarium semitectum* have not to our knowledge been reported from sugar beet. The majority of isolates in 2003 were from samples with yellowing symptoms. However, there was very little vascular discoloration in a number of these samples. Pathogenicity tests for these isolates are ongoing.

Over the three years of this project, a total of 305 *Fusarium* isolates have been obtained, with the majority (56%) being *Fusarium oxysporum*. Of the *F. oxysporum*, approximately 25% of the isolates tested to date are pathogenic on sugar beet. In addition, isolates of at least four other *Fusarium* species have been determined to cause yellows symptoms on sugar beet.

In addition to isolates from sugar beet, two *F. oxysporum* f. sp. *spinaciae* isolates were kindly provided by Dr. L. duToit. These isolates were obtained from spinach and had been demonstrated to be pathogenic on spinach. In greenhouse tests, both spinach isolates were pathogenic on sugar beet with a moderate level of virulence. This is consistent with the three *F. oxysporum* f. sp. *spinaceae* isolates obtained and tested previously.

Isolates of *F. oxysporum* so far obtained in this study include isolates from California, Colorado, Minnesota, Montana, Nebraska, North Dakota, Oregon, Washington, and Wyoming. Pathogenic isolates identified so far are from Colorado, Montana, Oregon, and Washington.

DNA has been extracted from all pathogenic isolates obtained in 2000 and 2001, as well as isolates provided by collaborators and used in RAPD analysis to examine genetic variability. Pathogenic isolates have been found to be a diverse group, with a higher amount of similarity general

found between pathogens from the same geographic area than between pathogens from different geographic areas.

To look for differences in host response in different isolates, isolates of *F. oxysporum* from different states, and one isolate of *F. solani*, were tested for virulence on *Fusarium*-susceptible sugar beet germplasm FC716 and two beet lines with reported resistance to Fusarium yellows. When the area under the disease progress curve (AUDPC) was determined for each of these isolates, variability was found between different isolates on the different beet lines (Figure 4). This demonstrates variability in the interaction between different *F. oxysporum* isolates and sugar beet lines. This is an indication of a probable race situation in this pathogen.
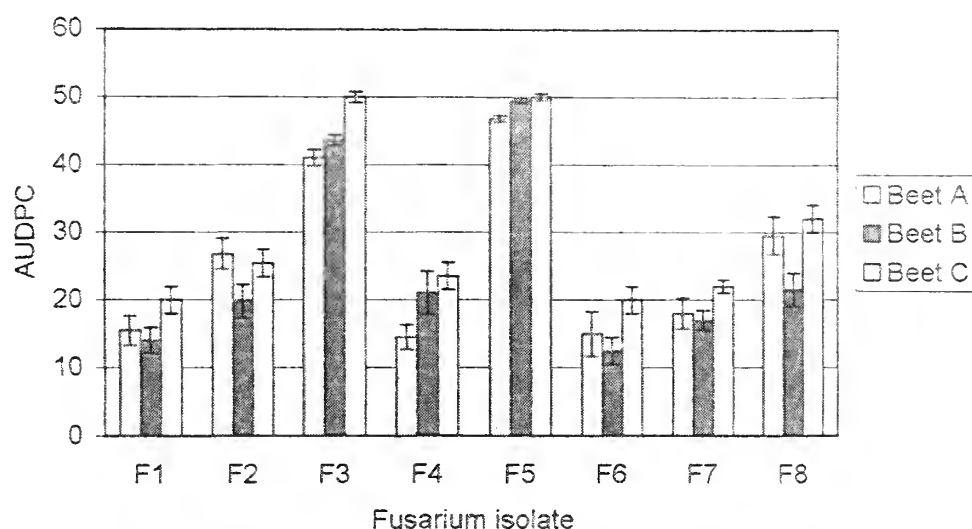
Figure 4. Area under the disease progress curve (AUDPC) for disease severity ratings for *F. oxysporum* isolates on three different sugar beet lines, two with reported resistance to *Fusarium oxysporum* (Beet A & B) and one susceptible (Beet C = FC716). Each point is an average from 10 plants. Isolate F1 is *F. solani*. Other isolates are *F. oxysporum*.

The finding of other species causing Fusarium yellows is of concern since current disease control measures are aimed at controlling *F. oxysporum*. Rotation with small grains and corn has been recommended for Fusarium yellows control, but *F. acuminatum, F. avenaceum* and *F. verticillioides* can be pathogens on small grains and *F. verticillioides* on corn. Thus these rotations might not aid in disease control.

The presence of several of these species on sugar beet also could be of concern for other crops grown in rotation with sugar beet, whether or not they cause disease on sugar beet. Several of the species isolated from sugar beet are generally reported to be grain pathogens. For example, *F. equiseti* was the second most commonly isolated species after *F. oxysporum*. While no isolates of this species were pathogenic on sugar beet, isolates of this species are important pathogens of cereal grains. Similarly, isolates of *F. avenaceum, F. acuminatum, F. culmorum, F. graminearum, F. scirpi* and *F. verticillioides* are pathogens of grains. At this time it is not known whether the isolates from sugar beet can affect these other crops, but this could be of concern for infection of crops in the rotation.

BSDF Project 440 – Rhizoctonia Root Rot Resistance and Development of Genetic Resistance in Sugar Beet

L. Panella & L. E. Hanson
Fort Collins, Colorado

Rhizoctonia root rot continues to be a problem in most sugar beet-growing areas in the United States, and is a growing problem world wide. The practice of short rotations and the expansion of growing areas into infested areas compound the problem. The result is a reduction in net returns to growers as well as processing losses due to reduced sucrose and purity of rotted or partially rotted beets. Genetic resistance, coupled with judicious cultural measures, is a more economical and practical method of reducing losses caused by this fungus than is a strictly chemical control regime. There is also a strong need of combining Rhizoctonia root rot resistance with Rhizomania resistance.

This has been an ongoing and productive project, and has been the only research project with the goal of discovering, developing, and releasing Rhizoctonia-resistant germplasm to industry breeders, our major external customers. Although several relatively resistant germplasms have been developed, we need to continue to combine this resistance with resistance to other diseases, and to develop a faster means of introgressing this resistance into more commercially acceptable materials.

Summary of Literature

Twenty-five years ago, Leach and Garber (1970) reviewed resistance to Rhizoctonia infection and concluded, "In general, while it has been possible to identify differences among cultivars or selections in susceptibility to Rhizoctonia infection, it is extremely rare that a high degree of resistance has been found or produced by selection or breeding within a susceptible host species." However, one of the most effective and environmentally safe ways to manage plant disease is with resistant germplasm (Sherf and MacNab, 1986). Soilborne pathogens like Rhizoctonia are often difficult to control chemically. Fumigation is expensive, providing only a temporary solution. The use of Quadris™[1] provides the first real chemical control for this disease. However, we are finding that timing of application is crucial. Additionally, spot spraying can be time consuming, and spraying a whole field because of a few patches of disease also can be expensive. The use of resistant germplasm, coupled with crop rotation and other cultural practices, can provide excellent management of diseases caused by *Rhizoctonia solani*.

In sugar beet (*Beta vulgaris* L.), Rhizoctonia root- or crown-rot is caused by *Rhizoctonia solani* (AG-2-2). Seedling damping-off in sugar beet primarily is caused by *R. solani* AG-4. Root-rot is endemic in sugar beet growing areas across the United States. John Gaskill began breeding for resistance in the late 1950s and released his first resistant germplasm in 1966 (Gaskill, 1968). Current Rhizoctonia resistant germplasm has a level of resistance in which there is no yield loss under disease pressure in the field (Ruppel and Hecker, 1994). It was realized early that natural field epiphytotics did not produce the necessary consistent, uniform disease pressure for recurrent mass selection (Pierson and Gaskill, 1961). Artificially induced epiphytotics (Ruppel et al., 1979; Schneider et al., 1982) were developed to provide uniform, heavy disease pressure to be able to perform mass selection or recurrent field selection (Hecker and Ruppel, 1977).

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[1]Mention of a trademark or manufacturer by the USDA does not imply its approval to the exclusion of other products or manufacturers.

The resistance to *R. solani* in sugar beet developed by John Gaskill is polygenic, involving at least two loci, two or three alleles, and modifying genes in some populations (Hecker and Ruppel, 1975). Broad-sense heritability has been estimated at about 0.65, and there are nonadditive components of the variance (Hecker and Ruppel, 1975). In a study by Hecker and Ruppel (1976) dominance effects were present in diploid, triploid, and tetraploid resistant hybrids. Relatively high heritability has aided in the development of increasing host plant resistance to Rhizoctonia root- and crown-rot, and we have released over 15 germplasm lines in the last 10 years. Rhizoctonia Resistance has been released in O-type maintainer, CMS female,. and multigerm-pollinator germplasm and remains a very important means of reducing crop damage by this disease (Herr, 1996). Genetic resistance to Rhizoctonia root rot has been an ongoing development from this project at Fort Collins. Several resistant germplasms have been released in the last five year to use as parents of hybrid cultivars or to provide source populations from which Rhizoctonia resistant parents were selected or which were crossed to provide resistant parents (Panella and Ruppel, 1996; Panella and Ruppel, 1997; Panella, 1999; Panella, 2001).

Epidemiological and control studies have been reported regularly from this project (Ruppel et al., 1988). Pathogen survival in varied crop debris and soil and the interaction of pesticides with Rhizoctonia have been reported on the literature (Ruppel, 1985; Ruppel 1991; Ruppel and Hecker, 1982; Ruppel et al., 1982). In a 3-year study, positive significant or highly significant correlations between disease severity indices and percent decreases in yield and purity parameters indicated that there were no hidden losses to Rhizoctonia root rot in our resistant germplasms (Ruppel and Hecker, 1994).

Recently, researchers attempting to determine the anastomosis group (AG) of *Rhizoctonia solani* isolates have used several new biotechnological techniques (including RFLP, RAPD, and isozyme analyses), with some notable successes in distinguishing among, and even within some, of these groups. Recently there was a report of a definitive assay to distinguish those isolates in AG-2-2 or AG-4 that cause sugar beet root rot and damping-off, respectively, from nonpathogenic isolates obtained from soil (Lubeck and Poulsen, 2001).

References

Gaskill, J. O. 1968. Breeding for Rhizoctonia resistance in sugarbeet. J. Am. Soc. Sugar Beet Technol. 15:105-119.

Hecker, R. J. and E. G. Ruppel. 1975. Inheritance of resistance to Rhizoctonia root-rot in sugarbeet. Crop Sci. 15:487-490.

Hecker, R. J. and E. G. Ruppel. 1976. Polyploid and maternal effects on Rhizoctonia root rot resistance in sugarbeet. Euphytica 25:419-423.

Hecker, R. J. and E. G. Ruppel. 1977. Rhizoctonia root-rot resistance in sugarbeet: breeding and related research. J. Am. Soc. Sugar Beet Technol. 19:246-256.

Herr, L. J. 1996. Sugar beet diseases incited by *Rhizoctonia* spp. Chap. V.10. In: *Rhizoctonia* Species: Taxonomy, Molecular biology, Ecology, Pathology and Disease Control. (Eds: Sneh, Baruch; Jabaji-Hare, Suha; Neate, Stephen; Dijst, Gerda) Kluwer Academic Publishers, Dordrecht, 341-350.

Leach, L. D., and R. H. Garber. 1970. Control of Rhizoctonia. In: *Rhizoctonia Solani*: Biology and Pathology.

(Ed: Parmeter, Jr, John R. J) University of California Press, Berkeley, 189-199.

Lubeck, M. and H. Poulsen. 2001. UP-PCR cross blot hybridization as a tool for identification of anastomosis groups in the *Rhizoctonia solani* complex. FEMS Microbiol. Lett. 201(1):83-89.

Panella, L. and E.G. Ruppel. Registration of FC725, FC726, AND FC728 sugarbeet germplasms resistant to Rhizoctonia root rot and moderately resistant to Cercospora leaf spot. Crop Sci. 36(3):819-820. 1996.

Panella, L. and E.G. Ruppel. Registration of sugarbeet germplasms FC721 and FC721CMS resistant to Rhizoctonia root rot and moderately resistant to the beet curly top virus. Crop Sci. 37(5):1675-1676. 1997.

Panella, L. Registration of FC709-2 AND FC727 sugarbeet germplasms resistant to Rhizoctonia root rot and Cercospora leaf spot. Crop Sci. 39(1):298-299. 1999.

Panella, L. Registration of FC712 (4X) tetraploid, multigerm sugarbeet germplasm. Crop Sci. in press. 2001

Pierson, V. G. and J. O. Gaskill. 1961. Artificial exposure of sugar beets to *Rhizoctonia solani*. J. Am. Soc. Sugar Beet Technol. 11:574-590.

Ruppel, E. G. 1985. Susceptibility of rotation crops to a root rot isolate of *Rhizoctonia solani* from sugar beet and survival of the pathogen in crop residues. Plant Dis. 69, 871-873.

Ruppel, E. G. 1991. Survival of *Rhizoctonia solani* in fallow field soil and buried sugarbeet roots at three depths. J. Sugar Beet Res. 28(3 & 4), 141-153.

Ruppel,E. G., R. L. Gilbertson and E. E. Schweizer. 1988. Population densities of selected soil-borne fungi and disease incidence in a crop rotation under varied weed-management systems. Agr. Ecosys. Envir. 21, 163-169.

Ruppel, E. G. and R. J. Hecker. 1982. Increased severity of *Rhizoctonia* root rot in sugar beet treated with systemic insecticides. Crop Protection 1(1), 75-81.

Ruppel, E. G. and R. J. Hecker. 1994. Rhizoctonia root rot on sugarbeet cultivars having varied degrees of resistance. J. Sugar Beet Res. 31:135-142.

Ruppel, E. G., R. J. Hecker and E. E. Schweizer. 1982. *Rhizoctonia* root rot of sugarbeet unaffected by herbicides. J. Am. Soc. Sugar Beet Technol. 21(3), 203-209.

Ruppel, E.G., C. L. Schneider, R. J. Hecker, and G. J. Hogaboam. 1979. Creating epiphytotics of *Rhizoctonia* root rot and evaluating for resistance to *Rhizoctonia solani* in sugarbeet field plots. Plant Dis. Rep. 63:518-522.

Schneider, C. L., E. G. Ruppel, R. J. Hecker, and G. J. Hogaboam. 1982. Effect of soil deposition in crowns on development of *Rhizoctonia* root rot in sugar beet. Plant Dis. 66:408-410.

Sherf, A. F. and A. A. MacNab. 1986. *Vegetable Diseases and Their Control*. Wiley, New York. 728 p.

OBJECTIVES:

1. Plant mother roots and selections for seed production and ultimate release to breeders for use as populations from which to develop Rhizoctonia- and rhizomania-resistant parents in hybrid cultivars.

2. Combine resistance to *Rhizoctonia* with that of other important pathogens (esp. Rhizomania) in germplasm with good agronomic performance.

3. Develop Rhizoctonia-resistant populations from different genetic sources of resistance.

4. A longer range goal (in collaboration with Mitch McGrath, USDA-ARS East Lansing) is the development of molecular markers linked to the genes in sugar beet controlling resistance to *R. solani.*

Materials and Methods:

Field isolation plots and greenhouse isolation chambers in Fort Collins will be used for seed production from mother roots and selections of advanced germplasms having been field selected for resistance to Rhizoctonia root rot. The Fort Collins environment has proven extremely valuable in these efforts. The arid climate, low organic matter content of the soils, and hot, dry winds are not conducive to the development of soilborne or foliar diseases. Therefore, when artificial epiphytotics, developed by Gaskill and Ruppel, are created to test sugarbeet for resistance to Rhizoctonia root rot there is little confounding of the results by the presence of other diseases.

Selected resistant populations resulting from crosses with material containing the single *Rz* gene source of resistance to Rhizomania will be sent to Salinas for field selection for Rhizomania resistance. Alternating cycles of selection in Salinas and Fort Collins (and Kimberley, ID for curly top resistance) will be used to increase disease resistance. Seed increases will be made and the germplasms will be released as adequate seed becomes available.

Molecular genetic studies will concentrate on looking at the response of the sugar beet to attack by *Rhizoctonia solani.* A longer range goal (in collaboration with Mitch McGrath, USDA-ARS East Lansing) is the development of molecular markers linked to the genes controlling resistance to *R. solani.* Populations are being developed at East Lansing for this purpose and molecular markers (SSRs & AFLPs) at both Fort Collins and East Lansing.

2003 Field Research on Rhizoctonia Root Rot of Sugar Beet

Annually, for over thirty years, the sugar beet breeding program in Fort Collins has included the production of an artificial epiphytotic through inoculation with *Rhizoctonia solani* to evaluate and select for resistance to root rot caused by this pathogen. We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF. In 2003, the project involved field studies conducted at the Crops Research Lab-Fort Collins Research Farm near Wellington, CO. Randomized, complete-block designs with five replicates were used to evaluate ARS breeding germplasm and Plant Introduction accessions. *Rhizoctonia*-resistant line FC703, highly resistant FC705-1, and highly susceptible FC901/C817 were included as internal

controls.

One-row plots, planted May 15th, were 14 feet long with 22 inches between rows and 8-10 inches within-row spacing. The field was sprayed twice with Betamix Progress, Upbeet, and Stinger (June 19 and 26) to control weeds. The field was thinned by hand and irrigated as necessary. Inoculation with dry, ground, barley-grain inoculum of *Rhizoctonia solani* AG-2-2 isolate R-9 was performed on July 10th; immediately after inoculation, a cultivation was performed so as to throw soil into the beet crowns. Beets were harvested August 27 through September 2. Each root was rated for rot on a scale of 0 to 7 (dead) as previously described. ANOVAs were performed on disease indices (DIs), percent healthy roots (classes 0 and 1 combined), and percentage of roots in classes 0 thru 3. Percentages were transformed to arcsin-square roots to normalize the data for analyses. LSDs are provided for comparing entries with those of our internal checks.

The high daytime temperatures in the summer of 2003 (Figure 1), combined with a moderate inoculum load, contributed to a severe root rot epidemic. Severe disease developed by late August. Mean DIs across all tests for highly resistant FC705-1, resistant FC703, and susceptible FC901/C817 controls were 3.2, 3.3, and 5.5 respectively. Mean DIs for these controls in 2002 were 1.8, 2.1 and 4.3 respectively. Percentages of healthy roots were 12.2, 8.7, and 1.4% for these controls. Percentages of roots in disease classes zero thru three were 57.4, 50.5, and 7.0, respectively. The highest and lowest DIs for the evaluated lines were 6.9 and 2.9, respectively.

Table 5.   Allotment of Fort Collins "FC" numbers (3-digit numbers)

"FC" numbers are "convenience" numbers for "seed releases" or purposes where a permanent line designation is needed — i.e. a number that does not change from generation to generation where little or no selection pressure is applied. Initially, an "FC" no. was written thus "FC 501" [now FC727], "FC 502 CMS" [now FC715CMS], etc. Sublines (from selfing) were designated thus, "FC 502/2" [now FC709-2], "FC502/3" [now FC502-3], etc. The same applies when the line is substantially changed by selection without selfing.

100's	Early releases
200's	Rhizoctonia, rhizomania resistant, combined with other resistances
300's	Leaf Spot Resistant (LSR), combined with rhizomania resistance
400's	Parental lines and special genetic stocks
Below 500	Originally LeRoy Powers -
500's	Leaf Spot Resistant (LSR), Type-O lines & male steriles [CMS]
600's	LSR-Curly Top Resistant (CTR), type-O lines & male steriles [CMS]
700's	Rhizoctonia Resistant
800's	LSR-CTR-Rhizoctonia resistant
900's	Pollinators, LSR-CTR type

Rhizoctonia-Resistant Populations Under Development

Rhizoctonia root rot continues to be a problem in most sugar beet-growing areas in the United States, and is a growing problem world wide. The practice of short rotations and the expansion of growing areas into infested areas compound the problem. The result is a reduction in net returns to growers as well as processing losses due to reduced sucrose and purity of rotted or partially rotted beets. Genetic resistance, coupled with judicious cultural measures, is a more economical and practical method of reducing losses caused by this fungus than is a strictly chemical control regime. There is also a strong need of combining Rhizoctonia root rot resistance with Rhizomania resistance.

This has been an ongoing and productive project, and has been the only research project with the goal of discovering, developing, and releasing Rhizoctonia-resistant germplasm to industry breeders, our major external customers. Although several relatively resistant germplasms have been developed, we need to continue to combine this resistance with resistance to other diseases, uncover new sources of resistance, and work to more quickly introgress this resistance into germplasm with higher sucrose yield potential.

Current Research 2003 – Germplasm under development:

With registration of FC724 and the release FC710 (4X), FC201 and FC301 in 2003 and early 2004, much of the germplasm remaining from the program of Dr. Richard Hecker will have been evaluated, improved and released or shelved. Current Rhizoctonia-resistant germplasm under development consists of populations being jointly developed with Dr. Robert Lewellen in Salinas (numbers one and two below). These populations are being improved to combine Rhizoctonia and Rhizomania resistance in a genetic background with good sucrose yield potential. Additionally, a population under development with Larry Campbell has the potential of providing root maggot resistance along with Rhizoctonia resistance.

FC201 Population:
1) Rhizoctonia-resistant monogerm polycross base population developed by a cross between FC708 and two Salinas germplasms, 2890 and 2859. **(Tested in Salinas as FC1014, FC1015).**

   a) 2890 (sp) 0790 *mm aa* x 1890 (Salinas); is seed from *aa* plants open pollinated by A-plants. 0790 = population-790 cycle 5 synthetic by S_1 progeny, M.S. mm, O-type, good combining ability, adapted to California, S^f,. 1890 = BC population to population 790 to get Rz equivalent, remains variable for M-:mm, Rz-:rzrz, etc.

   b) 2859 m (sp) = 1859, 1859R aa x A- (Salinas); Released in 1992 as C859. S^f, similar to 2890, but should have higher curly top resistance (CTR). Segregates and variable for M-:mm, Rz-:rzrz, A-:aa, predominant background is lines like C563, which is widely used in western USA as source of CTR, mm, O-type.

2) Rhizoctonia root rot resistance multigerm base population developed by a cross between FC709-2 and a Salinas germplasms, 2915. **(Tested in Salinas & Fort Collins as FC1030).**

   a)   2915 (sp) RZM 1915-#m 1913-# aa x A (Salinas); Seed harvested from aa (ms) plants

open-pollinated by A- (fertile) plants. This population will segregate for A-:aa, Rz-:rzrz, $s^s s^s : s^f$-, ($> \frac{1}{2} s^f$), R-:rr, It will be multigerm, have moderate to good tolerance to virus yellows, curly top, bolting, Erwinia; variable for reaction to powdery mildew, production traits. Individual plants will be either Aa or aa. Background of population is mostly from OP, MM lines such as C46, C37.

Progress in 2003

1. Final testing and seed increase of monogerm O-type lines with and without CMS equivalents, selected in the 1996 Rhizoctonia nursery, were completed and two of those lines have been released and the rest are to be released in the summer (listed above). (Tables 6 and 7 below).

2. This population (FC708/2890&2859) was divided into three breeding lines. One has been selected for resistance to curly top (selfed progeny tested in Kimberley, ID) and Rhizoctonia (individual plants selected in the Fort Collins nursery), and is currently being increased for testing and re-selection. Another population has been selected for resistance only to Rhizoctonia (individual plants selected in the Fort Collins nursery), and is currently being increased for testing and re-selection. The third line was selected for Rhizomania resistance and agronomic performance (individual plants selected in the Salinas nursery) and has been released as FC201 (tested as FC1014 & FC1015 in Salinas).

3. This population (FC709-2/2915) was divided into four breeding lines selected in Fort Collins, CO, and Kimberley, ID. Two have been selected for resistance to Rhizoctonia (individual plant selections and half-sib families selections), one was selected for resistance to Rhizoctonia and curly top virus (half-sib families selections), and one was selected for resistance to curly top (half-sib families selections). Three of the populations were planted in Dr. R. Lewellen's Rhizomania/steckling nursery for selection for resistance to rhizomania (Rz – Holly gene source) and for agronomic performance. Selected roots will be increased for further sucrose and rhizomania testing, selection, and release.

4. Selections made in a (FC709-2 x FC907)F_2 population in the Rhizoctonia nursery were increased in the greenhouse and tested in the Rhizoctonia root rot, Cercospora leaf spot and curly top nurseries. This population will be re-selected for percent sucrose and increased for release.

5. A number of accessions from the NPGS *Beta* collection that had shown Rhizoctonia-resistance in the Sugarbeet CGC screening program have been identified. Those PIs with seed available were re-screened in 2003. Special attention will be paid to those accessions screened in 1987 and 1992 because the tests in those years appear to have been unreliable. Crosses will be made between any that appear to have resistance using a female parent with high sucrose yield potential and with Rhizomania resistance. The goal is to develop Rhizoctonia-resistant populations from potentially different sources of resistance, from which breeders will be able to select resistant hybrid parents or germplasm to cross into programs developing Rhizoctonia-resistant hybrid parents (See tables 8 and 9 below).

Table 6. Experiment 5R, 2003. Rhizoctonia Evaluation of USDA-ARS Fort Collins Experimental and Released Germplasm.

Entry	Seed Source	Release Description	DI[1]	% Hlthy[2]	% 0 - 3[3]	Z%[4] Hlthy	Z% 0 - 3[4]
		(<4.16 significantly better than susceptible check) LSD[5]	0.94			13.7	20.6
		CV	18.6			75.0	47.9
		Susceptible Check[6]	5.1	9	18	8.5	16.7
		Experiment Mean	4.0	12	37	14.5	34.2
		Highly Resistant Check[7]	3.2	19	55	23.0	48.0
		Resistant Check[8]	3.2	17	56	21.1	48.8
767	19961014	FC724 New Release 2003	2.3	35	82	35.5	68.2
770	20001016H	FC709-2	2.6	27	72	31.2	58.2
764	19891033	FC710	2.7	19	76	23.3	64.4
766	20001022	FC710(4X)	3.0	10	70	16.6	58.4
765	19971017	FC710(4X)	3.3	17	44	15.9	41.6
760	19921019	FC729 – FC712/A4, 3 cycles Rhizoc, MM	3.4	12	51	15.3	45.4
757	20021018HO	FC712/Mono-Hy A4	3.4	19	51	23.0	45.8
752	20011007	F3 (907 x 709-2) for RhzcR - hs 10A-1775	3.6	9	45	15.4	41.8
751	19961015	FC720-1-- C718/(C718/FC708)	3.8	11	38	17.4	37.8
768	20021001H	Increase of LSR EL & FC polycross	3.9	13	41	18.0	39.5
758	20021018HO1	FC712/MonoHy A4 CMS	4.0	17	34	18.3	34.8
763	951016HO1	FC723CMS – EL44/FC708 CMS	4.1	10	35	16.2	32.4
756	20011003HO1	FC712/MonoHy A4 CMS	4.3	9	24	11.5	23.2
755	20011003HO	FC712/Mono-Hy A4	4.5	5	21	7.8	23.5
761	961010HO1	FC722CMS – C718/FC708CMS	4.8	1	13	3.1	18.2
762	951016HO	FC723 – EL44/FC708 mm	4.8	3	11	5.9	14.8
769	20011060	[FC712 x 9931(Salinas)] F2	5.1	2	12	3.3	13.1
753	20011013H	F4 (907 x 709-2) for RhzcR - hs 10A	5.7	3	10	4.2	11.4
759	20021028	FC709-2 x 9933 (root aphid resistant, Salinas)	6.0	0	0	0.0	0.0
754	20021002	RhzcR/mR - (FC907 x FC709-2) x 9931	6.1	0	0	0.0	0.0

[1]Disease Index is based on a scale of 0 (=healthy) to 7 (= plant dead).
[2]Percent of healthy roots (disease classes 0 and 1 combined).
[3]Percent of diseased roots likely to be taken for processing (disease classes 0 through 3 combined).
[4]Percentages were transformed to arcsin-square roots to normalize the data for analyzes.
[5]P=0.05; There were 6 missing plots, however LSD was estimated as if all plots were present.
[6]FC901/C817 - susceptible check
[7]FC705/1 - highly resistant check
[8]FC703 - resistant check

Seed Source	Identification	DI[1]	% Hlthy[2]	% 0 - 3[3]	Z% Hlthy[4]	Z% 0 - 3[4]
	Susceptible Check[6]	**5.2**	**3**	**7**	**4**	**10**
	Highly Resistant Check[7]	**3.5**	**12**	**51**	**13**	**43**
	Resistant Check[8]	**3.5**	**20**	**42**	**18**	**40**
	Experiment Mean	**5.14**	**3.6**	**12.8**	**4.5**	**14.6**
(<4.03 significantly better than susceptible check) LSD[5]		**1.17**			**13.7**	**20.3**
	CV	**18.1**			**243.6**	**111.1**
y290	RZM - % YO9O, C1, Syn 2	5.9	0	3	0	6
y275	RZM - % YO75, SBxBVM	5.7	0	7	0	9
2933	RZM - % 99933 (A,aa) CO gp	6.4	0	3	0	4
01-FC1030	RZM FC©#1, 915aaxFC709	3.7	9	40	11	39
01-FC123	RZM OO-FC123 mmaaxA	5.7	0	0	0	0
02-FC124	RZM 01-FC123H7	6.4	0	0	0	0
01-FC1014	RZM 00-FC1014 mmaaxA	5.4	0	5	0	10
02-FC1015	RZM 01-FC1014H7	5.2	0	10	0	19
01-FC1014-22	00-FC1014 mmaaXA, HS	5	0	11	0	19
01-FC1014-26	00-FC1014 mmaaXA, HS	4.7	4	19	7	22
01-FC1014-28	00-FC1014 mmaaXA, HS	5.2	0	11	0	15
	Yellow beet	6	5	8	6	8
	Yellow beet	6.1	0	3	0	5
01-FC1030-15	FC1030 aaxA, HS	4.2	5	25	8	29
01-FC1030-16	FC1030 aaxA, HS	4.8	2	17	6	18
ARS Michigan	EL50	4.4	6	17	9	22
ARS Michigan	USH20	5.1	2	10	4	12
ARS Michigan	SR80	5.1	3	8	4	13
ARS Michigan	SR87	4.9	6	14	7	16
ARS Michigan	SR93	5.4	2	4	4	6
ARS Michigan	SR94	5	5	20	6	18
ARS Michigan	SR95	5.3	2	4	4	5
ARS Michigan	SR96	6	0	1	0	3
ARS Michigan	SR97	5.6	0	0	0	0
ARS Michigan	EL0204	4.9	13	17	11	15
ARS Michigan	01B024-MIX	4.9	7	13	9	16

Table 7. Experiment 4R, 2003. Rhizoctonia Evaluation of USDA-ARS Salinas, East Lansing and Fort Collins Experimental and Released Germplasm.

[1]Disease Index is based on a scale of 0 (=healthy) to 7 (= plant dead).
[2]Percent of healthy roots (disease classes 0 and 1 combined).
[3]Percent of diseased roots likely to be taken for processing (disease classes 0 through 3 combined).
[4]Percentages were transformed to arcsin-square roots to normalize the data for analyzes.
[5]P=0.05; There were 6 missing plots, however LSD was estimated as if all plots were present.
[6]FC901/C817 - susceptible check
[7]FC705/1 - highly resistant check
[8]FC703 - resistant check

Table 8. Experiment 2R, 2003. Rhizoctonia Resistance Evaluation of Plant Introductions.

Source	subspecies	Donor's ID	DI[1]	% Hlthy[2]	% 0 - 3[3]	Z%[4] Hlthy	Z% 0 - 3[4]
(<3.99 significantly better than susceptible check)		LSD[5]	1.0			9.5	18.9
		CV	15.07			235.5	77.7
		Susceptible Check[6]	4.99	0.00	13.00	0.0	18.7
		Highly Resistant Check[7]	2.97	9.60	71.40	13.9	63.8
		Resistant Check[8]	2.99	13.80	67.40	19.6	56.3
		Experiment Mean	5.36	2.30	19.64	3.2	19.5
PI 504250	*maritima*	SD wild beet..........................	6.80	0.00	0.00	0.0	0.0
PI 504251	*maritima*	SD wild beet..........................	6.75	0.00	3.25	0.0	5.3
PI 504266	*maritima*	SD wild beet..........................	5.90	2.00	21.60	3.7	21.3
PI 504268	*maritima*	SD wild beet..........................	5.62	0.00	28.00	0.0	25.8
PI 504270	*maritima*	SD wild beet..........................	6.54	0.00	8.60	0.0	11.0
PI 504271	*maritima*	SD wild beet..........................	6.48	1.60	7.40	3.3	9.8
PI 518407	*maritima*	SD IDBBNR 5901	6.05	4.00	12.60	5.3	13.7
PI 518429	*maritima*	SD IDBBNR 5923	6.54	0.00	4.20	0.0	5.5
PI 518432	*maritima*	SD IDBBNR 5926	6.60	0.00	0.00	0.0	0.0
PI 518437	*maritima*	SD IDBBNR 5931	6.56	0.00	0.00	0.0	0.0
PI 518438	*maritima*	SD IDBBNR 5932	6.19	0.00	7.60	0.0	10.2
PI 518439	*maritima*	SD IDBBNR 5933	6.11	0.00	8.00	0.0	7.9
PI 546511	*maritima*	SD IDBBNR 9678	6.92	0.00	1.60	0.0	3.3
PI 546521	*maritima*	SD IDBBNR 9688	6.27	0.00	13.80	0.0	16.6
PI 546526	*maritima*	SD IDBBNR 9693	5.63	0.00	25.20	0.0	29.6
PI 546529	*maritima*	SD IDBBNR 9696	6.53	0.00	3.60	0.0	5.0
PI 546534	*maritima*	SD IDBBNR 9701	6.64	0.00	3.20	0.0	6.5
PI 546537	*vulgaris*	SD IDBBNR 9704	6.38	0.00	5.20	0.0	8.3
PI 546538	*vulgaris*	SD IDBBNR 9705	5.79	1.80	8.80	3.5	10.7
PI 552532	*vulgaris*	SD 'F1012............................	6.05	0.00	4.00	0.0	7.3
PI 558514	*vulgaris*	SD FC 402	6.11	0.00	0.00	0.0	0.0
PI 558515	*vulgaris*	SD FC 403	5.20	0.00	9.80	0.0	11.8
PI 558513	*vulgaris*	SD FC 401	5.63	0.00	0.00	0.0	0.0
PI 285592	*vulgaris*	SD Crassa Strzelecki I	5.01	2.80	19.40	4.4	20.7
PI 285593	*vulgaris*	SD Crassa Udycki Zolty..........	3.79	0.00	45.80	0.0	42.0
PI 285594	*vulgaris*	SD Crassa Walcowaty..........	4.08	0.00	42.60	0.0	37.6
PI 285595	*vulgaris*	SD Crassa Walcowaty..........	3.92	2.60	31.20	4.2	30.7
PI 293419	*vulgaris*	SD Podzimniaja 0474	3.96	10.00	39.40	12.0	38.3
PI 293420	*vulgaris*	SD Bordo 237	3.94	6.20	38.80	9.2	35.2
PI 357357	*vulgaris*	SD Okrugla	3.82	2.60	48.60	4.2	43.3
PI 357360	*vulgaris*	SD Ohdiska Zolta..................	3.49	8.00	50.20	10.6	45.1
PI 357361	*vulgaris*	SD Gostivarska Zelena	4.40	4.00	31.00	5.3	33.0
PI 531260	*vulgaris*	SD Bordo...............................	3.03	13.60	48.00	16.3	40.9
PI 535826	*vulgaris*	SD Gigant Poly......................	4.80	4.00	15.80	5.3	18.2
PI 535845	*vulgaris*	SD Annomono.......................	5.71	0.00	0.00	0.0	0.0

[1] Disease Index is based on a scale of 0 (=healthy) to 7 (= plant dead).
[2] Percent of healthy roots (disease classes 0 and 1 combined).
[3] Percent of diseased roots likely to be taken for processing (disease classes 0 through 3 combined).
[4] Percentages were transformed to arcsin-square roots to normalize the data for analyzes.
[5] P=0.05; There were 6 missing plots, however LSD was estimated as if all plots were present.
[6] FC901/C817 - susceptible check
[7] FC705/1 - highly resistant check
[8] FC703 - resistant check

Table 9. Results of a Query of the GRIN database for sugarbeet accessions with a Rhizoctonia score less than or equal to 3.

NPGS ID	Accession Name	Other names	Year(s) Evaluated	Score
PI 285590	Epipski HOSER		1987	3
PI 285593	Crassa Udycki Zolty Walcowaty		1987	3
PI 285594	Crassa Walcowaty Zolty Granum		1987	3
PI 285595	Crassa Walcowaty Zolty Pzhr		1987	3
PI 293419	Podzimniaja 0474		1987	3
PI 293420	Bordo 237		1987	3
PI 357357	Okrugla		1987	3
PI 357360	Ohridska Zolta		1987	3
PI 357361	Gostivarska Zelena		1987	3
PI 546390	WB 69	IDBBNR 5591	1990	3
PI 546510	WB 771	IDBBNR 9677	1992	3
PI 546524	WB 790	IDBBNR 9691	1992	3
PI 546527	WB 793	IDBBNR 9694	1992	3
PI 546530	WB 796	IDBBNR 9697	1992	3
PI 546531	WB 797	IDBBNR 9698	1992	3
PI 546532	WB 798	IDBBNR 9699	1992	3
PI 546533	WB 799	IDBBNR 9700	1992	3
PI 546537	WB 787	IDBBNR 9704	1992	3
PI 546538	WB 788	IDBBNR 9705	1992	3
PI 546539	WB 789	IDBBNR 9706	1992	3
PI 552532	F1012	IDBBNR 9707	1992	3
PI 558505	FC 506	IDBBNR 9711	1992	3
PI 558513	FC 401	IDBBNR 9714	1992	3
PI 558515	FC 403	IDBBNR 9716	1992	3
PI 531260	Bordo		1996	3
PI 535826	Gigant Poly		1996	3
PI 535845	Annomono		1996	3
PI 285592	Crassa Strzelecki I Har		1987 & 1998	3 & 8

Lines released for Rhizoctonia Resistance contained within the database.

NPGS ID	Accession Name	Other names	Year(s) Evaluated	Score
PI 607379	FC712(4X)	NSL 362030	1999	3
PI 590766	FC712	IDBBNR 4591	1999	3
PI 518643	FC709	IDBBNR 9603	1999	3
PI 590754	FC705/1	IDBBNR 4571	1995 & 1999	1 & 3
PI 591336	FC 728	921025	1999	3
PI 574630	FC 719	IDBBNR 9769	1999	3
PI 599668	FC 709-2	NSL 362030	1999	2

BSDF Project 441 – Cercospora Leaf Spot Research and Breeding for Cercospora and Curly Top Resistance

L. Panella & L. E. Hanson
Fort Collins, Colorado

This element of the breeding program at Fort Collins is devoted to the development of germplasm with resistance to more than one sugar beet disease and improved agronomic characteristics. It is built on germplasm developed at Fort Collins over the last fifty years for combined resistance to Cercospora leaf spot and the curly top virus. This is an integrated breeding program with greenhouse and laboratory studies, and a field program based on testing in an artificial epiphytotic created in the unique Fort Collins environment. It involves close collaboration with the other USDA-ARS sugar beet programs in the U.S. and sugar beet seed industry customers. The major goals of this program are: 1) the development of sugar beet germplasm with resistance to more than one disease and excellent agronomic characteristics; 2) the improvement of breeding techniques, traditional and molecular, to develop this germplasm; and 3) an increased understanding of the sugar beet/pathogen interactions to improve management practices of these diseases in sugar beet production areas. Genetic information developed during this research will be used to execute additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our leaf spot improvement program. Results of these tests will be the basis of decisions about specific germplasm, i.e., retain, discard, recombine, release, etc. Germplasms likely to be useful for variety improvement will be identified and released for use by other sugar beet breeders.

Increased resistance to *Cercospora* continues to be an extremely important goal. If the level of resistance available in most Cercospora-resistant experimental lines were present in commercial hybrids (along with good sugar and seed yield), the need for fungicides would be greatly reduced. That continued improvement in genetic resistance to this serious pathogen is still needed, is evident by the occurrence of *Cercospora* strains that are resistant or increasingly tolerant to our most potent fungicides. Additionally, some of these fungicides may be removed from the market because of their perceived or real threat to the environment. In many areas where Cercospora leaf spot is a problem, the curly top virus also causes significant losses. And, there are some growing areas in which combined resistance to Cercospora leaf spot, Rhizomania, curly top, Rhizoctonia root rot, and other diseases are desirable. Germplasm is needed with combined resistance to these diseases, along with good combining ability for yield components.

2002 Field Research on Cercospora Leaf Spot of Sugar Beet

The breeding program in Fort Collins has created an annual artificial epiphytotic through inoculation with *Cercospora beticola* for over forty years. This epiphytotic has been used to evaluate and select for resistance to leaf spot caused by *C. beticola*. We have been pleased to participate in and lead this cooperative research project between the ARS, Colorado State University, and the BSDF.

In 2003, the field studies were conducted at the Irrigation Research Center near Yuma, CO. Randomized complete-block designs, with three replications, were used to evaluate commercial and experimental entries. Internal controls included a highly susceptible synthetic (SP351069-0) and a resistant check (FC504CMS/FC502-2//SP6322-0). Two-row plots were 12 feet long, with 22-inch row spacing and an 8- to 10-inch within-row plant spacing. The trial was planted on May 6.

Inoculations were performed on July 16 and July 23. Evaluations were made on August 29, September 5, 12, and 19, with the peak of the epidemic occurring between the second and third date. The field was sprayed twice with Betamix Progress, Upbeet, and Stinger (June 12 and 23) to control weeds. The field was irrigated as necessary.

The high temperatures in the summer of 2003 and low moisture (Figure 2) contributed to a moderate leaf spot epidemic, which did not become severe enough to rate until the end of August. Disease severity increased through the first two weeks of September. By the third rating (September 12), means of the resistant and susceptible internal control were 3.5 and 5.8 (scale of 0-10), respectively across the nursery. In 2002 (September 25), these means were 3.8 and 4.5, respectively. Means of contributor lines in 2003 ranged from 3.0 to 7.3.

Cercospora/Curly Top-Resistant Populations with Resistance to Multiple Sugar Beet Diseases and Superior Agronomic Characteristics

Germplasm under Development:

Cercospora Leaf Spot/Curly Top Resistant (LSR/CTR) Breeding Populations Currently Under Development.

FC301 population

1. Cercospora leaf spot and curly top resistant monogerm base population from a polycross of FC607 and FC604 with two Salinas germplasms 2859 and 2890 **(Tested in Salinas as FC123)**.

   A. 2890 (sp) = 0790 *mm aa* x 1890 (Salinas); is seed from *aa* plants open pollinated by A-plants. 0790 = population-790 cycle 5 synthetic by S_1 progeny, *aa*, mm, O-type, good combining ability, adapted to California, S^f. 1890 = BC population to population 790 to get Rz equivalent, remains variable for M-:mm, Rz-:rzrz, etc.

   B. 2859 m (sp) = 1859, 1859R aa x A- (Salinas); Released in 1992 as C859. S^f, similar to 2890, but should have higher curly top resistance. Segregates and variable for M-:mm, Rz-:rzrz, A-:aa, predominant background is lines like C563.

2. Cercospora leaf spot and curly top resistant multigerm base population from a polycross of FC902 with two Salinas germplasms 278 and 4918.

   C. 278 (Iso 83) = RZM R078; R278 is Rz (segregates Rz--:rzrz) version of C46. It should be S^sS^s, MM.

   D. 4918 (sp) = RZM 3918aa X A-, 142 aa plants; This is an increase of released material C918. It should be Multigerm, over 75% S^f and segregating for A-, R-, Rz-, VY, CT, Erw, & PM.

3. Cercospora leaf spot and curly top resistant multigerm, self-incompatible base population from a polycross of FC607 x [SR87, MonoHy A4, MonoHy T6, & MonoHy T7]

4. Seed from FC709-2 x FC907 was sent to Larry Campbell at Fargo to cross to Sugar beet root maggot resistant germplasm to develop a population that will produce pollinators with resistance to Rhizoctonia, Cercospora, and Root maggot.

5.   Two tetraploid pollinators (FC6064X and FC6074X) were crossed to a high sucrose tetraploid population in order to produce a tetraploid Cercospora resistant pollinator population with better combining ability.

Progress in 2003

Advanced breeding lines of *Cercospora* resistant germplasms were evaluated in the ARS leaf spot nursery at Yuma. These lines are part of the resistant germplasm development effort in which a new germplasm should be released from the "pipeline" every two to four years. The above populations currently are in different stages of development.

1.   FC301 was released from this population; other selections from ½ sib progeny rows based on combined leaf spot and curly top resistance (FC607&FC604/2859&2890) of the monogerm (FC123mm) and multigerm (FC123MM) population were planted in the 2003 mother root nursery for increase. Material sent to Salinas, CA and showed good rhizomania resistance and progeny families have been selected sucrose.

2.   Plants (F_2) from the CTR/LSR multigerm cross (2 above – FC902/278/4918) were tested for resistance to Rhizoctonia and Cercospora and recombined. This seed has been bulk increased and crossed with a number of other leaf spot, rhizomania resistant and high sources populations. The resulting population will be a source of curly top resistant multigerm pollinators with leaf spot and rhizomania resistance. This cross was planted in the Salinas rhizomania resistance nursery for selection and also has been selected for agronomic performance and recombined. It will be tested and evaluated for release or re-selection.

3.   Plants (F_2) from the Fort Collins and Fargo joint project (3 above – FC607 x [SR87, MonoHy A4, MonoHy T6, & MonoHy T7]) were grown in the breeding nursery and these roots were planted in Masonville selfed, taking advantage of the 'pseudo self-fertility' that occurs in this environment. This selfed seed was progeny tested in 1999 and the most resistant families were recombined and are being tested and evaluated for release. This population will be a source of highly leaf spot resistant multigerm pollinators with curly top resistance and good combining ability for agronomic traits

4.   Seed from (FC709-2 x FC907)F_2 has been sent to Larry Campbell at Fargo to cross to Sugar beet root maggot resistant germplasm and be selected for Cercospora resistance. This population will be reselected for Rhizoctonia resistance. The population will provide pollinators with resistance to Rhizoctonia, Cercospora, and Root maggot. This material will be screened in Fargo in 2003.

5.   Seed from this population (FC6064X & FC6074X/high sucrose 4X) will be planted in the 2004 mother root nursery and ½ sib families produced in 2004 for selection in the Cercospora leaf spot nursery and for sucrose & yield in 2005.

Table 10. Experiment 3A, 2003. Leaf Spot Evaluation of USDA-ARS E. Lansing contributed lines.

Entry	Identification		Disease Index[1]			
			August 29th	September 5th	September 12th	September 19th
		LSD$_{0.05}$	1.06	0.88	1.02	0.80
332	LSS[2] (931002)		6.0	8.0	7.3	6.7
333	LSR[3] (821051H2)		1.5	4.0	4.0	3.3
	Trial Mean		2.6	4.7	4.7	4.2
321	EL50		1.0	3.0	3.0	3.0
322	USH20		2.8	4.7	4.7	4.3
323	SR80		1.3	3.0	3.3	3.0
324	SR87		1.8	3.7	4.0	3.7
325	SR93		2.7	5.0	5.3	4.3
326	SR94		2.8	5.0	4.7	4.3
327	SR95		3.0	5.7	6.0	5.7
328	SR96		3.7	4.7	5.0	4.3
329	SR97		2.3	4.7	4.7	4.0
330	EL0204		3.7	5.3	5.3	4.7
331	OIB024-MIX		1.5	4.0	4.0	3.3

[1] Disease Index is based on a scale of 0 (=healthy) to10 (=dead).
[2] The Leafspot Susceptible Check is SP351069-0.
[3] The Leafspot Resistant Check is ((FC504CMS x FC502/2) x SP6322-0).

Table 11. Experiment 4A, 2003. Leaf Spot Evaluation of USDA-ARS Salinas contributed lines.

Entry	Identification	Disease Index[1] August 29th	September 5th	September 12th	September 19th
	LSD$_{0.05}$	0.86	0.85	0.76	0.66
368	LSS [2] (931002)	3.5	5.0	5.0	5.0
369	LSR [3] (821051H2)	1.0	2.7	3.3	3.0
	Trial Mean	2.2	3.9	4.1	4.3
341	Beta4430R	5.0	6.0	6.7	6.0
342	Monohikari	3.3	4.3	5.0	4.7
343	Y290	2.0	3.8	3.8	4.0
344	Y275	2.0	4.0	4.3	5.0
345	R221	2.0	3.7	5.0	4.8
346	2933	1.7	3.7	4.0	4.0
347	2933-14	1.3	3.7	3.0	3.7
348	2933-17	1.8	3.7	4.0	4.3
349	2933-7	2.0	3.7	4.0	4.7
350	CR211	1.8	3.3	3.7	4.0
351	CR009-1	1.2	3.3	3.0	4.0
352	CR211-7	1.7	3.3	3.0	3.3
353	CR210-2	2.2	3.3	3.3	4.0
354	CR214	2.3	3.7	5.0	5.0
355	01-FC1030	1.3	3.3	4.0	4.0
356	2842	2.3	3.7	4.2	4.7
357	01-FC123	2.2	4.0	4.0	4.0
358	02-FC124	2.0	4.0	4.0	4.3
359	01-FC1014	1.8	4.3	4.0	4.3
360	02-FC1015	2.0	4.0	4.3	4.3
361	yellow beet	1.8	4.0	4.0	4.3
362	yellow beet	2.5	4.7	4.3	4.7
363	yellow beet	2.8	4.7	4.0	4.3
364	01-FC123-23	1.5	3.3	4.0	4.0
365	01-FC123-31	3.0	3.3	4.0	4.0
366	yellow beet	2.3	4.0	4.7	4.7
367	yellow beet	2.3	4.3	3.7	4.3

[1] Disease Index is based on a scale of 0 (=healthy) to 10 (=dead).
[2] The Leafspot Susceptible Check is SP351069-0.
[3] The Leafspot Resistant Check is ((FC504CMS x FC502/2) x SP6322-0).

Table 12. Experiment 5A, 2003. Leaf Spot Evaluation of USDA-ARS Fort Collins contributed lines.

Seed source	Identification	Disease Index[1]			
		August 29th	September 5th	September 12th	September 19th
	LSD$_{0.05}$	0.85	1.01	0.93	0.73
LSS[2] (931002)		5.0	6.3	5.7	5.0
LSR[3] (821051H2)		1.0	3.0	3.0	2.7
Trial Mean		1.9	3.9	3.7	3.8
19831085HO	FC708	1.3	3.7	3.0	3.0
19911026HO	FC715	1.0	3.0	3.0	3.0
19921021	FC703-5	1.7	4.0	3.7	3.7
19921022	FC702-7	2.5	4.7	3.7	4.0
19921025	FC728	1.8	3.7	3.7	3.3
1997AO50	FC607	1.2	3.7	3.0	3.0
19981025	FC717	1.5	3.3	3.3	4.0
20001016H	FC709-2	1.0	3.3	3.3	3.3
19951017	FC727	2.3	4.2	4.7	4.0
951016HO	FC723 - EL44/FC708mm	2.5	4.7	4.5	4.0
951016H01	FC723 CMS - EL44/FC708 CMS	1.7	4.0	3.7	4.0
961010H0	FC722-1 - C718/FC708	1.5	4.0	3.3	4.0
961010H01	FC722 CMS - C718/FC708 CMS	1.5	3.7	3.3	4.0
19961014	FC724 New Release 2003	1.5	3.0	3.0	3.3
20011007	F$_3$ hs 10A-1775 (907 x 709-2)	1.8	4.3	3.3	3.7
20011060	[FC712 x 9931(Salinas)] F2	3.0	4.0	4.0	4.3
19921019	FC729 - FC712/A4, 3 cycles Rhizoc, MM	2.0	4.0	4.0	3.7
20021002	RhzcR/mR - (FC907 x FC709-2) x 9931	2.8	5.0	4.7	4.7
20001017	FC720-1	1.5	3.0	3.0	3.3
19891033	FC710	1.8	3.7	3.3	3.3
19971017	FC710(4X)	1.2	3.0	3.3	4.0
20001022	FC710(4X)	1.3	4.0	3.7	3.3
20021001H	Increase of LSR EL & FC polycross	1.2	3.0	3.0	3.3
20011003HO	FC712/MonoHy A4	2.2	4.3	3.7	4.0
20011003H01	FC712/MonoHy A4 - CMS equivalent	2.7	4.3	4.3	4.3
20021018HO	FC712/Mono-Hy A4	1.8	4.0	3.3	3.7
20021018H01	FC712/MonoHy A4 CMS	2.5	4.2	4.2	4.2
911043HO	FC403	3.0	5.0	5.0	4.7
911043H01	FC403CMS	2.8	4.3	4.7	4.3
20001007	LSR w/ Fargo	1.0	3.7	3.0	3.3
20021028	FC709-2 x 9933 (root aphid resistant, Salinas)	1.8	3.7	3.0	4.3
20021037	Best FC LSR/EL LSR x CR011 (LSR/RhzmR)	1.3	4.0	3.7	4.0
20021038	Best FC LSR/EL LSR x CR910 (LSR/RhzmR)	1.3	3.3	4.0	3.7

[1]Disease Index is based on a scale of 0 (=healthy) to10 (=dead).
[2]The Leafspot Susceptible Check is SP351069-0.
[3]The Leafspot Resistant Check is ((FC504CMS x FC502/2) x SP6322-0).
Note: means and LSD are for entire plot, which included additional lines not shown on this table

BSDF Project 443 – Pre-breeding: the Introgression of New Sources of Cercospora Leaf Spot Resistance from *Beta Vulgaris* ssp. *maritima* and other Exotic Sources into Sugar Beet-type Populations.

Lee Panella

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A major emphasis of the research mission of the USDA-ARS plant scientists is the collection, documentation, characterization, evaluation, regeneration (maintenance), distribution, and utilization of plant germplasm, especially Plant Introduction (PI) accessions in the USDA-ARS National Plant Germplasm System (NPGS). The Sugar Beet Research Unit at Fort Collins is coordinating the national program for *Beta* germplasm evaluation. In addition to the evaluation for Rhizoctonia and Cercospora resistance, it is crucial that ARS scientists be involved in the long rang, high risk research problems involved in sugar beet 'germplasm enhancement' or 'pre-breeding' from exotic germplasm or wild relatives. This is an important component in the overall sugar beet improvement effort of the Fort Collins Sugar Beet Research Unit.

Justification for Research:

Cercospora leaf spot (caused by the fungus *Cercospora beticola* Sacc.) is one of the most widespread diseases of sugar beet and is a serious problem in many sugar beet production areas throughout the U.S. The disease damages the leaves, which, consequently, reduces root yield, percent sucrose of roots, and purity of the extracted juice. Cercospora leaf spot currently is controlled by combining spraying with commercial fungicides and the use of disease tolerant germplasm. The development of Cercospora leaf spot resistant sugar beet lines and hybrids with greater levels of host-plant resistance offers a more sustainable solution to this disease problem.

If the level of resistance available in some Cercospora-resistant experimental breeding lines were present in commercial hybrids **(along with good sugar and seed yield)**, the need for fungicides could be greatly reduced. That continued improvement in genetic resistance to this serious pathogen is still needed, is evident by the occurrence of *Cercospora* strains that are tolerant to our most potent fungicides. Additionally, some fungicides may be removed from the market because of their perceived or real threat to the environment.

Finally, the genepool for resistance to Cercospora leaf spot is extremely narrow. Many of the resistant lines are highly inbred, i.e., closely related to one another, and stem from germplasm coming out of Italy in the early 1900s. In the germplasm developed at Fort Collins, continued inbreeding has increased the level of disease resistance, but at the cost of plant vigor. Over the long term, a secure, sustainable response to this disease requires commercial quality hybrids with good host-plant resistance.

Summary of Literature Review:

Cercospora leaf spot (CLS) has been an intermittent problem in sugar beet growing areas of the United States where the summers can be hot and humid (Red River Valley, Michigan, Ohio, and, less often, Great Plains growing areas and California). It has been estimated that a severe epidemic can cause up to a 42% loss of gross sugar (Smith and Martin, 1978; Smith and Ruppel, 1973), or up to a 43% relative dollar loss (Shane and Teng, 1992).

Resistance to CLS has long been a goal of the USDA-ARS sugar beet research program at Fort

Collins and researchers there developed the techniques necessary to manage the screening nurseries in such a way as to promote the development of the disease (Ruppel and Gaskill, 1971). A careful crop rotation (sugar beet-barley-barley-barley-sugar beet) and the arid climate and low relative humidity have allowed this to be done in such a manner that there are rarely high enough levels of any other disease present in the leaf spot nursery to confound the results. The resistance to CLS could more accurately be described as a tolerance, rather than true resistance. Tolerance or "field resistance" means that, although some symptoms of the disease are present, the plant still is able to perform well (Fehr, 1987 p.307).

Much of the Cercospora-resistant germplasm in use today came out of Munerati's program in Italy, in which *B. vulgaris* spp. *maritima* was the source of resistance genes (Lewellen, 1992). In this genetic source, there are an estimated 4 or 5 genes responsible for CLS resistance (Smith and Gaskill, 1970) and broad-sense heritability estimates ranged from 12 to 71% (Bilgen et al., 1969). Narrow-sense heritability estimates of about 24% compared well with realized heritability values, and 44 to 62% of the variation was due environment in this test (Smith and Ruppel, 1974). The large environmental variation has made it difficult to make progress in developing resistance through mass selection. Incorporation of high levels of leaf spot resistance into varieties with superior agronomic performance also is difficult (Smith and Campbell, 1996) and, therefore, commercial resistant varieties require some fungicide application to provide adequate levels of protection against Cercospora (Miller et al., 1994).

A major problem in the development of CLS-resistant sugar beet is the loss of vigor due to the continual inbreeding. Coons (1955) noted this and it has been a concern ever since (McFarlane, 1971). The use of hybrid varieties has ameliorated this problem to some extent, but seed production on the highly inbred O-type males and CMS females still is a problem. This creates an urgent need to continue to develop a broader genetic base in our CLS-resistant germplasm than we have today. Also as commercial hybrid parents become more inbred, the germplasm base from which these inbred parents are developed must have the diversity necessary to provide for maximum gain through heterosis. In addition to broadening the genetic base of the commercial sugar beet germplasm, novel genes for resistance to CLS might lead to transgression of the currently available tolerance to CLS. Simply defined, transgression is when a population contains individuals with a phenotype that is beyond the phenotype found in the parents of the population (de Vicente & Tanksley, 1993).

The USDA-ARS National Plant Germplasm System Beta collection has over 2,000 Plant Introduction (PI) accessions. The germplasm used most often in sugar beet breeding is from *Beta vulgaris* spp. *vulgaris*, which includes all of the biennial sugar beet types, or from *Beta vulgaris* spp. *maritima*, which contains the closely related wild sea beet and has both annual and biennial types. Germplasm with a biennial flowering habit is easier both to introgress and screen. *Beta vulgaris* spp. *maritima* has, nonetheless, been used as a source of resistant germplasm. There have been very few new efforts to locate and incorporate other sources of resistance to Cercospora into this narrow germplasm base. Munerati's success, and the research of others, has shown that it can be done if we have the persistence to do it (Bilgen et al., 1969; Doney, 1993; Lewellen, 1995).

References

Bilgen, T., J.O. Gaskill, R.J. Hecker, and D.R. Wood. 1969. Transferring Cercospora leaf spot resistance from Beta maritima to sugarbeet by backcrossing. J. Am. Soc. Sugar Beet Technol. 15:444-449.

Coons, G.H., F.V. Owen, and D. Stewart. 1955. Improvement of the sugar beet in the United States. Adv. Agron. 7:89-139.

de Vicente, M. C. and S. D. Tanksley. 1993. QTL analysis of transgressive segregation in an interspecific tomato cross. Genetics 134(2), 585-596.

Doney, D.L. 1993. Broadening the genetic base of sugarbeet. J. Sugar Beet Res. 30:209-220.

Fehr, W. R. 1987. Principles of Cultivar Development. 1st ed. Vol. 1. Macmillan Publishing Company, New York. 536 pages.

Lewellen, R.T. 1992. Use of plant introductions to improve populations and hybrids of sugarbeet. p. 117-135. In: Use of Plant Introductions in Cultivar Development. Crop Science Society of America, Madison, WI.

Lewellen, R.T. 1995. Performance of near-isolines of sugarbeet with resistance to Rhizomania from different sources. Proceedings of the 58th Congress of the International Institute for Beet Research. pp.83-92. Presses Universitaires de Bruxelles a.s.b.l., Bruxelles.

McFarlane, J.S. 1971. Variety development, p. 402-435. In: R.T. Johnson, J.T. Alexander, G.E. Rush, and G.R. Hawkes (eds.). Advances in Sugarbeet Production: Principles and Practices, 1st ed. The Iowa State University Press, Ames,IA.

Miller, J., M. Rekoske, and A. Quinn. 1994. Genetic resistance, fungicide protection and variety approval policies for controlling yield losses from Cercospora leaf spot infections. J. Sugar Beet Res. 31:7-12.

Ruppel, E.G. and J.O. Gaskill. 1971. Techniques for evaluating sugarbeet for resistance to Cercospora beticola in the field. J. Am. Soc. Sugar Beet Technol. 16:384-389.

Shane, W.W. and P.S. Teng. 1992. Impact of Cercospora leaf spot on root weight, sugar yield, and purity of Beta vulgaris. Plant Dis. 76:812-820.

Smith, G.A. and L.G. Campbell. 1996. Association between resistance to Cercospora and yield in commercial sugarbeet hybrids. Plant Breeding 115:28-32.

Smith, G.A. and J.O. Gaskill. 1970. Inheritance of resistance to Cercospora leaf spot in sugarbeet. J. Am. Soc. Sugar Beet Technol. 16:172-180.

Smith, G.A. and S.S. Martin. 1978. Differential response of sugarbeet cultivars to Cercospora leaf spot disease. Crop Sci. 18:39-42.

Smith, G.A. and E.G. Ruppel. 1973. Association of Cercospora leaf spot, gross sucrose, percentage sucrose, and root weight in sugarbeet. Can. J. Pl. Sci. 53:695-696.

Smith, G.A. and E.G. Ruppel. 1974. Heritability of resistance to Cercospora leaf spot in sugarbeet. Crop Sci. 14:113-115.

Objectives:

1. The formation of long range breeding populations through the introgression of Cercospora resistant germplasm from "exotic" sources (*Beta vulgaris* ssp. *maritima*, fodder beet, foreign sugar beet landraces from the PI collection, etc.).

2. The development of germplasm populations from these long range populations that are of sufficient agronomic quality to be of use to commercial breeders. They will be a source of leaf spot resistance with different genetic backgrounds.

3. The development of techniques (both traditional and molecular) to more efficiently introgress the exotic germplasm into sugar beet breeding populations.

Materials and Methods:

Artificial field inoculation with Cercospora beticola and leaf spot scoring will be used to identify the resistant germplasm sources and make selections in the developing populations. The exotic materials will be crossed into sugar beet populations that have been selected for agronomic quality (recoverable sucrose yield). These sucrose populations are based on old commercial varieties – i.e., MonoHy T6, A7, A4 and breeding lines from American Crystal Sugar Co. and Seedex, Inc. – and USDA-ARS developed germplasm such as L-19 (WC9127OM) and East Lansing smooth root germplasm , SR87. Other parents include high sucrose germplasm from Poland and other Eastern European countries. Salinas parent '3859' was used to produce populations that are self-fertile (S^f) and segregating for nuclear male sterility (A-:aa).

Hybrid populations will be handled in the following manner: 1) Following the initial cross, a population will be random mated (using aa females because of the self-fertility) for three to four generations to break up linkage groups and remove annual plants. 2) Sugar beet-type mother roots will be selected, selfed, and progeny tested for agronomic performance and disease resistance. 3) Selected roots will be recombined (and backcrossed if desirable) and re-selected until they ready for release. Molecular markers (RFLPs, RAPDs, SSRs, AFLPs, etc.) as they become available will be used to expedite the backcrossing program and to follow the change in allele frequencies in the selected populations. Advanced populations will be released to the sugar beet seed industry.

Time Line of Anticipated Accomplishments:

Development of a resistant germplasm line generally takes seven years. A longer time will be necessary to incorporate disease resistance from more exotic sources. Because this is a new program,

it will take time for the first germplasm to make it through the process. Once that happens, there will be a "pipeline" of germplasm in various stages of development and the release of new germplasm will occur every two to four years. The incorporation of exotic sources into agronomically acceptable germplasm is a long term proposition - results will not appear overnight. This is the type of long-term germplasm development that ARS is well suited to perform.

Research Progress 2003:

We have increased or made crosses in eighteen populations listed below (See table below). All of the male parents are germplasm that have been identified as having resistance to *Cercospora beticola* (causal agent of Cercospora leaf spot). The female parents are from a population developed to have high sucrose yield potential. These sucrose populations are based on old commercial varieties – i.e., MonoHy T6, A7, A4 and breeding lines from American Crystal Sugar Co. and Seedex, Inc. – and USDA-ARS developed germplasm such as L-19 (WC9127OM) and East Lansing smooth root germplasm , SR87. Other parents include high sucrose germplasm from Poland and other Eastern European countries. Salinas parent '3859' was used to produce populations that are self-fertile (S^f) and segregating for nuclear male sterility (A-:aa). The families from various crosses are in different stages of development and evaluation. At the F_3 stage, when sufficient seed is available, we are beginning field screening and selection. Seed of these families has been bulk increased and is beginning to be evaluated (Tables 13, 14, and 15). All show some annual plants in our environment.

We are re-crossing some of those from which we obtained insufficient F_1 seed. Plants from those populations producing some biennial plants are being vernalized for 90 days and the populations are being increased (i.e., random mated using the genetic male sterility where possible). The annuals will be handled in a similar fashion once the F_1 populations have been increased. All will be cycled through at least three cycles of random mating.

The most advanced populations were screened for resistance to Cercospora leaf spot and curly top. Leaf spot evaluations showed good levels of resistance for some of the populations and some also showed resistance to the curly top virus. All of the populations are still segregating for biennial growth habit, easy bolting, and other wild traits.

Table 13. Breeding lines from the USDA-ARS Fort Collins breeding program tested in the BSDF Curly Top Nursery in Kimberly, ID in 2002.

Seed Source	Description		Disease Index*	
			17 Aug	31 Aug
		EXPERIMENT MEAN	2.65	2.90
96A008	Beta G6040 - Resistant Check		2.00	2.00
931017	Susceptible Check - FC901/C817		2.83	2.83
		CV	22.2	23.8
		LSD	ns	1.113
20001022	FC710(4X) - LSR Tetraploid		2.00	2.17
741026H	High Sucrose x maritima		2.17	2.33
20011008HO	FC502-2		2.17	2.33
20011054	(SucroseMM x PI540605)F_2		2.67	2.50
20001016H2	(FC708CMS X FC709-2)		2.58	2.50
20011045PF	(SucroseMM x PI540599)F2		2.50	2.67
20011045MS	(SucroseMM x PI540599)F2		2.58	2.67
20011002bbMS	LSR (France) x SucroseMM - aa biennial segregants		2.83	2.92
20011002bbPF	LSR (France) x SucroseMM - A_ biennial segregants		3.00	3.33
751099H	L-19		3.67	4.17

*Disease Index (DI) scale = 0 (no symptoms) to 9 (plant death).

Table 14. Experiment 7A, 2002. Leaf Spot Evaluation of USDA-ARS Fort Collins breeding lines.

Entry	Identification	Entry	Disease Index[1]			
			Sept. 5rd	Sept. 14th	Sept. 19th	Sept. 25th
	LSD$_{0.05}$		ns	ns	ns	0.87
	CV		37.4	24.4	18.7	14.3
	LSS [2,4] (931002)		3.0	4.0	4.5	5.0
	LSR [3] (821051H2)		1.7	3.3	3.7	3.7
	Trial Mean		1.7	3.0	3.4	3.7
20011045MS	(SucroseMM x PI540599)F2	519	1.3	2.3	3.0	3.0
20011045PF	(SucroseMM x PI540599)F2	520	1.5	2.7	3.0	3.2
20011002bbMS	LSR (France) x SucroseMM - aa biennial segregants	514	1.3	3.0	3.0	3.3
20001016H	FC709-2	508	1.0	2.0	3.0	3.3
20001016H2	(FC708CMS X FC709-2)	528	1.0	2.3	3.0	3.3
20011002bbPF	LSR (France) x SucroseMM - A_ biennial segregants	515	2.0	3.0	3.7	4.0
20011054	(SucroseMM x PI540605)F2	521	1.7	3.3	3.0	4.0
911043HO	FC403	533	2.7	4.0	4.3	4.3

[1] Disease Index is based on a scale of 0 (=healthy) to 10 (=dead).
[2] The Leafspot Susceptible Check is SP351069-0.
[3] The Leafspot Resistant Check is ((FC504CMS x FC502/2) x SP6322-0).
[4] The Leafspot Susceptible Check was missing on plot but LSD was calculated as if all three plots were there.

Table 15. List of germplasm used in developing Cercospora leaf spot resistant populations and the stage of each of the populations.

Accession Number (♂)	♀ parent	Donor (♂) Designation	Name or Origin (♂)	% Bolting (♂) no induction 1996 FC, CO	F_1 Population	F_2 Population	F_3 Population	F_4 Population	F_5 Population
96A010	961005	PI 535826	Giant Poly	20%	971021H2	981031	991026	20011027MS	20031013
96A011 971022H	961005 19991024H2	PI 535833	Saturn	0%	--- 20031001H2				
96A014	961005	PI 540593	WB 847	0%	971023H2	20021026			
96A015	961005	PI 540596	WB 850	70%	971024H2	981032	20011026bbPF 20011026bbMS		
96A017	961005	PI 540605	WB 859	25%	971025H2	20011054	20031014		
96A012	961005	PI 535843	PN MONO 1	100%	971026H2[1]				
96A013	961005	PI 540575	WB 829	100%	971027H2[2]				
96A016	961005	PI 540599	WB 853	50%	971028H2	981033	20011045bbPF 20011045bbMS		
94A079	961005	BGRC #32375 (B. v. maritima)	Greece	annual	971029H2	20011036			
94A080	961005	BGRC #36538 (B. v. maritima)	Greece	annual	971030H2[3]	20011037			
94A081	851046HO	BGRC #45511 (B. v. maritima)	Greece	annual	981001H3	20011038B_ 20011038bb			
94A081 981001H	961005 19991024H2	BGRC #45511 (B. v. maritima)	Greece	annual	--- 2001046H2	20021036B_ 20021036bb			

Table 15. List of germplasm used in developing Cercospora leaf spot resistant populations and the stage of each of the populations.

Accession Number (♂)	♀ parent	Donor (♂) Designation	Name or Origin (♂)	% Bolting (♂) no induction 1996 FC, CO	F$_1$ Population	F$_2$ Population	F$_3$ Population	F$_4$ Population	F$_5$ Population
94A082	851046HO	BGRC #45516 (B. v. maritima)	Greece	annual	981002H3	20011039B 20011039bbPF 20011039bbMS			
94A082 981002H	961005 19991024H2	BGRC #45516 (B. v. maritima)	Greece	annual	--- 20021033H2				
94A083	961005	BGRC #48810 (B. v. maritima)	Tunisia	annual	19981003H2	20011040B 20011040bb	20021030B 20021030bb	20031038B 20031038bb	
94A083	851046HO	BGRC #48810 (B. v. maritima)	Tunisia	annual	981003H3	200110141B 200110141bb			
94A084	961005	BGRC #48819 (B. v. maritima)	Tunisia	annual	981004H2	20011042B 20011042bb	20021031B 20021031bb	20031039B 20031039bb	
94A084 981004H	961005 19991024H2	BGRC #48819 (B. v. maritima)	Tunisia	annual	--- 20021034H2				
94A085 981005H	961005 19991024H2	BGRC #51430 (B. v. maritima)	Greece	annual	--- 20021035H2				

[1] Only 16 seed balls produced.
[2] Only 10 seed balls produced.
[3] Only 60 seed balls produced.

SUGARBEET RESEARCH

2003 Report

SECTION C

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PUBLICATIONS
Abstract of Papers Presented or Published

Campbell, L.G., and Klotz, K.L. 2003. Impact of Sugar Beet Root Diseases on Postharvest Storage. Proceedings of the 1ˢᵗ Joint IIRB-ASSBT Congress, 27 February-1 March, 2003, San Antonio, TX. P. 409-414.

In recent years, the sugarbeet (Beta vulgaris L.) root diseases, Aphanomyces and rhizomania (causal agents Aphanomyces cochlioides Drechal. and Beet Necrotic Yellow Vein Virus, respectively), have become more prevalent throughout Minnesota and eastern North Dakota. Accompanying any increase in root disease in the field will be an increase in the proportion of diseased roots placed in storage piles. Information on the effects of root disease on initial quality and storability would, therefore, assist growers and agriculturalists when determining the disease severity that would justify not harvesting a field or if roots from diseased fields should be segregated and processed first. Respiration rate, extractable sucrose per ton, and the formation of carbohydrate impurities were determined in roots exhibiting varying degrees of Aphanomyces or rhizomania symptoms. Respiration rates of roots with moderate or severe Aphanomyces were substantially higher than respiration rates of healthy roots. The concentrations of the invert sugars, glucose and fructose, were also elevated in severely rotted roots, although trisaccharide impurity concentrations were reduced. The higher respiration rates of Aphanomyces infected roots are not only indicative of higher sugar loss but would also increase storage pile temperatures and increase sugar loss in adjacent healthy roots. Further sucrose loss would occur during the processing of rotted roots due to their increased concentrations of invert sugars. Initial observations of the effects of rhizomania on sugarbeet root storage properties suggest that rhizomania is not nearly as detrimental to root storability as Aphanomyces, however, this indication is based on a single year's data. The impact of genetic resistance on storage properties.

Klotz, K.L., and Campbell, L.G. 2003. Comparison of Sucrose Catabolism in Roots of Three *Beta Vulgaris* L. Genotypes with Different Yield and Sucrose Accumulating Capacities. Proceedings of the 1ˢᵗ Joint IIRB-ASSBT Congress, 27 February-1 March, 2003, San Antonio, TX. P. 505-509.

Sucrose catabolism is a major determinant of sink strength in nearly all plants and affects sucrose partitioning to growing sinks as well as sink size and carbohydrate content. Three enzyme families are responsible for nearly all sucrose catabolism in sugarbeet roots: acid invertase, alkaline invertase and sucrose synthase. Previous work suggested that sucrose synthase may have a role in sink strength and root size in sugarbeet. To examine this observation more thoroughly, sucrose catabolism was compared in three Beta vulgaris genotypes with contrasting capacities for root yield and sucrose accumulation. Soluble acid invertase, cell wall acid invertase, alkaline invertase and sucrose synthase activities were compared at five stages of root

development in a fodder beet hybrid (high yield, low sucrose content), a commercial sugarbeet hybrid (typical yield and sucrose content) and the sugarbeet breeding line, L19 (low yield, high sucrose content). Sucrose, glucose and fructose concentrations and mass accumulation were also determined. Generally, sucrolytic activity was greatest in the high yielding fodder beet and lowest in the low yielding L19 breeding line at any stage of development. Sucrose synthase activity was the predominant sucrolytic activity at all stages of development examined, and accounted for 90% or more of the total sucrolytic activity in fodder beet and sugarbeet hybrid roots by six weeks after planting and in L19 eight weeks after planting. Total sucrose synthase activity was positively correlated with nonextractable dry matter accumulation. Differences in sucrose concentration between genotypes were observed, although sucrose concentration or accumulation was not highly correlated with any of the major sucrolytic enzymes examined.

Klotz, K.L., Anderson, M.D., and Finger, R.L. 2003. Contribution of Cytochrome *C* and Alternative Oxidase Pathways to Respiratory Sucrose Loss in Postharvest Sugarbeet (*Beta Vulgaris* L.) Roots. Proceedings of the 1st Joint IIRB-ASSBT Congress, 27 February-1 March, 2003, San Antonio, TX. P. 915-919.

It is estimated that respiration is responsible for approximately 70% of the sucrose loss that occurs during postharvest storage of sugarbeet roots. Respiration provides the metabolic energy and carbon substrates needed to maintain healthy tissue during storage, heal wounds acquired during harvest and defend against pathogens. Two respiratory pathways, the cytochrome c oxidase pathway and the alternative oxidase pathway, contribute to total respiration. In sugarbeet, little information is available on the role of these two pathways in sucrose utilization and postharvest losses. This information, however, would improve our understanding of this physiological process and may provide insight into methods to reduce postharvest respiratory sucrose loss. Analyses of the changes in total respiration and the contribution of the two pathways in sugarbeet roots subjected to different storage conditions and durations, and in response to typical harvest stresses are in progress. Initial results indicate that the cytochrome c respiratory pathway predominates in healthy unwounded and wounded sugarbeet roots, and that the relative capacities of the two pathways change little in response to wounding, time in storage, or storage temperature. Respiration was approximately 8-fold higher at the root surface and 1.5-fold higher in the internal tissue of the crown than in the root internal tissue.

Klotz, K.L., Finger, R.L., and Anderson, M.D. 2003. Induction of Respiration by Wounding Is Temperature Dependent in Sugarbeet (*Beta Vulgaris* L.) Root. Plant Biology 2003 Abstracts, 25-30 July, 2003, Honolulu, Hi. Abstract #283. P.81.

The respiration rate of harvested plant products is largely influenced by temperature and wounding. In sugarbeet root, respiration rate is positively associated with storage

temperature and the extent of wounding during the harvest and delivery of roots. An investigation into the underlying physiology of this phenomenon revealed that the wound induced increase in respiratory tissue activity was temperature dependent. Respiration was measured as O2 consumption at 25 degrees C in tissue sections taken 1 cm below the root epidermis. Wounded roots incubated at 10 degrees C exhibited increased respiration over unwounded roots throughout the thirteen days of incubation, with maximum respiration occurring two days after wounding. Wounding had no influence on respiratory activity at 1 degree C. Determination of the capacities of cytochrome c oxidase and alternative oxidase respiratory pathways using isolated mitochondria and respiratory pathway specific inhibitors revealed a three to four-fold increase in cytochrome c oxidase capacity and a two to five-fold increase in alternative oxidase capacity at both 1 degree and 10 degrees C. The data suggest that the lack of a respiratory wound response at 1 degree was not due to a general reduction in metabolic activity or limiting mitochondrial respiratory capacity at the lower temperature. Similarly, an increase in phosphofructokinase activity in wounded roots was observed at 10 degree, but not at 1 degree C.

Lartey, R.T., Weiland, J.J., Caesar, T, Bucklin-Comiskey, S.A. A PCR Protocol for Rapid Detection of Cercospora beticola in Sugarbeet Tissues. Journal of Sugarbeet Research. 2003. V. 40. P. 1-10.

Leaf spot, caused by Cercospora beticola. Sacc. is the most important foliar disease of sugarbeet (Beta vulgaris L), yet the progression of infection from soil to diseased leaves remains incompletely understood. A method for sensitive detection of C. beticola on disease-free plants could be used to determine how early in the growing season sugarbeet tissues are colonized by the fungus and to what extent asymptomatic weeds and non-beet crops harbor the fungus. We present an Extract-N-Amp Plant PCR Kit (Sigma)-based protocol for rapid detection and identification of C. beticola in plant tissues. Leaf disks from field-sampled diseased tissues or disease-free greenhouse plants were homogenized and diluted with manufacturer-provided extraction and dilution solutions. Without further DNA purification, aliquots of the homogenate were added to PCR reactions and subjected to amplification using the Cercospora actin gene specific and ITS region based primers. Fragment sizes of the amplified products correlated with the size of that amplified from DNA extracted from C. beticola cultures. Sequences alignment of the amplified products confirmed them to be that of C. beticola. The system will enable rapid detection and identification of C. beticola in asymptomatic and diseased sugarbeet, in alternate hosts and soil debris that harbor the fungus.

Weiland, J.J. Host-pathogen Interactions in the Phytopathogenic Aphanomyces. Proceedings 2nd International Aphanomyces Symposium. 2003. P. 43-49.

Bulk assay and gel activity assays were used to characterize proteases secreted by Aphanomyces cochlioides and A. euteiches both in culture and in infected seedlings. Using bulk assays, inhibitors of trypsin-like enzymes were capable of reducing sample protease activity, whereas inhibitors for other protease classes had no effect. Non-denaturing sodium dodecylsulfate polyacrylamide gel electrophoresis separated protease isozymes secreted by A. cochlioides into 7-8 resolvable bands whereas those secreted by A. euteiches were resolved into 6 bands. Incorporation of trypsin-class inhibitors either into the electrophoresis gels or into the activity staining buffer resulted in a decrease of activity for the fastest migrating isozymes. The involvement of protease activity in the infection of plants by Aphanomyces and the implications for disease control are discussed.

Weiland, J.J., Yu, MH a Cleaved Amplified Polymorphic Sequence (Caps) Marker Associated with Root-Knot Nematode in Sugar Beet. Crop Science. 2003. V. 43. P. 1814-1818.

Resistance to root-knot nematode (Meloidogyne spp.) was introgressed into sugarbeet (Beta vulgaris L.) from wild beet [B. vulgaris ssp. maritima (L.) Arcang] and was demonstrated to be dominant and simply inherited. Since resistance conferred by this gene was effective against six different species of Meloidogyne spp. tested, the locus was designated R6m-1 for resistance to 6 species of Meloidogyne spp. Sugarbeet population 1568, an inter-pollinated progeny population of resistant heterozygotes segregating for R6m-1, was inoculated with J2 nematodes and rated for root knot disease in a greenhouse. Resistance vs. susceptibility segregated at approximately 4:1 ratio, and 120 of the resistant roots and 48 of the susceptible roots were chosen for the generation of molecular marker linked to the resistance trait. Bulked DNA samples prepared from shoots sprouting from the selected plants were subjected to RAPD analysis, yielding a marker of 600 bp that was highly associated with resistance. Sequence comparison between the product generated from resistant plants and susceptible plants revealed numerous nucleotide substitutions. One base substitution associated in repulsion with resistance conditioned the existence of a recognition site for cleavage by the restriction endonuclease Mse 1. Amplification and cleavage of the product with Mse 1 yielded a cleaved amplified polymorphic sequence (CAPS) marker designated Nem06 that segregated 100% with resistance to the root knot nematode.

POLYMERASE CHAIN REACTION (PCR)-BASED DETECTION OF FUNGAL PATHOGENS USING ACTIN GENE SEQUENCES.
Project 620

John J. Weiland

The polymerase chain reaction (PCR) is a DNA based technique for amplifying specific sequences from the genomes of organisms. PCR technology has impacted many fields of biology, including the area of disease diagnosis in both plants and animals. Diagnostics using the PCR are sensitive and highly discriminatory, since they target genome regions whose DNA sequences have diverged throughout evolution. PCR-based diagnostics also require little time for a result to be secured (within one to two days), making them attractive to high-throughput diagnostic laboratories. More recently, exquisite quantitation of pathogens has been made a reality by the added technology of "real-time" PCR, a technology currently being used in our laboratory for the quantitation of gene expression and fungal genomes.

The interests in our laboratory include the development of novel diagnostic tools for disease-causing fungi in sugarbeet with a special emphasis on the highly destructive pathogen *Aphanomyces cochlioides.*. For this reason, we designed our PCR assay for the discrimination of sugarbeet fungal pathogens upon DNA sequences of the actin and ribosomal RNA (rRNA) genes. The rRNA genes of all organisms harbor sequences that permit that organism to be "fingerprinted" according to that gene sequence. This fingerprinting analysis was applied to Aphanomyces populations that were collected in the U.S. ranging from the northern Red River Valley to (now abandoned) sugarbeet growing regions of Texas. The analysis revealed that *Aphanomyces cochlioides* populations in the central states of the U.S. are genetically uniform. Because of this, we sought to examine *A. cochlioides* isolates from a more localized region that nevertheless has some unique attributes. Sugarbeet grown in the Southern Minnesota Beet Sugar Cooperative region is, in some cases, rotated with fields of green pea and with table beet. *A. euteiches* is a well known pathogen of peas in this area. In addition, it is known that *A. cochlioides* can infect table beet. We therefore collected soil samples from these regions in 2003 and have produced DNA preparations from 85 single-zoospore isolates from these samples. The genetic diversity of these isolates will be determined and compared to results obtained from previous studies.

Also in 2003, the cloning and sequencing of the actin genes of a large set of fungal pathogens of sugarbeet (causing both field and storage disease) was completed and the results condensed (Figure 1). These sequences have been confirmed, by homology search against public sequence databases, to encode actin genes. The actin gene for *C. beticola* generated in our research is available in the NCBI-Genbank public sequence database with accession number AF443281. The sequences are presented here for use in the design of DNA primers that might be used for the detection of these fungal pathogens in healthy and diseased plants and in soil.

>Aphanomyces cochlioides consensus (actin confirmed)
GAATTCGCCCTTGTATGTGCAAGGCCGGTTTTGCCGGTGACGATGCCCCCCGCGCCGTCT
TTCCTTCCATTGTTGGTCGCCCCAAGCACCCTGGTATCATGGTTGGCATGGACCAAAAGG
ATGCCTATGTCGGTGATGAAGCCCAATCCAAGCGTGGTGTCTTGACTTTGAAGTACCCTA
TTGAACACGGTATTGTGACCAACTGGGACGATATGGAGAAGATTTGGCACCACACTTTCT
ACAACGAATTGCGTGTCGCACCTGAAGAACACCCTGTGTTATTGACGGAAGCTCCATTGA
ACCCCAAGGCCAACCGTGAACGCATGACCCAAATCATGTTCGAAACCTTCAACGTGCCTG
CCATGTATGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCTGGTCGTACCACTGGTT
GCGTGTTGGACTCTGGTGATGGTGTCTCCCACACTGTGCCCATCTACGAAGGTTACGCTC
TTCCCCACGCTATTGTCCGTTTGGACTTAGCTGGTCGCGACTTGACCGACTTCATGATGA
AGATCTTGACCGAACGTGGTTACTCCTTCACCACC-ACCGCTGAACGCGAAATCGTGCGT
GACATCAAGGAAAAGTTGACATACGTCGCTCTCGACTACGACCAAGAGATGAAGACCGCT
GCCGAATCTTCGGGTCTCGAAAAGAGCTACGAATTGCCCGATGGTAACGTCATTGTCATC
GGCAACGAACGTTTCCGTACCCCTGAAGTGTTGTTCCAACCTTCCTTGATCGGTAAGGAA
GCTTCGGGTATCCACGACTGCACCTTCTCGACCATCATGAAGTGCGATGTCGATATCCGT
AAGGACTTGTACTGCAACATCGTGTTGTCCGGCGGTACCACCATGTACCCTGGTATCTCG
GAACGTATGACCAAGGAATTGACCGCCTTGGCTCCTTCCACCATGAAGATCAAGGTTGTC
GCTCCTCCTGAGCGCAAGTACTCCGTCTGGATCGGTGGTTCAAGGGCGAATTC

>Aphanomyces euteiches consensus (actin confirmed)
GAATTCGCCCTTGTATGTGCAAGGCCGGTTTTGCCGGTGACGATGCCCCCCGCGCCGTCT
TTCCTTCCATTGTCGGTCGCCCCAAGCACCCTGGTATCATGGTTGGCATGGACCAAAAGG
ATGCCTATGTCGGTGATGAAGCTCAATCCAAGCGTGGTGTCTTGACCTTGAAGTACCCTA
TTGAACACGGTATTGTGACCAACTGGGACGATATGGAAAAGATTTGGCACCACACTTTCT
ACAACGAATTGCGTGTCGCCCCTGAAGAACACCCTGTGTTGTTGACGGAAGCTCCTTTGA
ACCCCAAGGCCAACCGTGAACGCATGACCCAAATCATGTTCGAAACCTTCAACGTGCCTG
CCATGTACGTGAACATCCAAGCCGTGTTGTCTTTGTACGCTTCCGGCCGTACCACTGGTT
GCGTGTTGGACTCTGGTGATGGTGTCTCCCACACTGTGCCCATCTACGAAGGTTATGCTC
TTCCCCACGCTATTGTCCGTTTGGACTTGGCTGGTCGCGACTTGACCGACTTCATGATGA
AGATCTTGACCGAACGTGGTTACTCCTTCACCACCACCGCCGAACGCGAAATCGTGCGTG
ACATCAAGGAAAAGTTGACCTACGTCGCTCTCGACTACGACCAAGAAATGAAGACCGCTG
CCGAATCTTCGGGTCTCGAAAAGAGTTACGAATTGCCTGATGGTAACGTCATTGTCATCG
GCAACGAACGTTTCCGTACCCCTGAAGTGTTGTTCCAACCTTCCTTGATCGGTAAGGAAG
CTTCGGGTATCCACGACTGCACCTTCTCGACCATCATGAAGTGCGATGTCGATATCCGTA
AGGACTTGTACTGCAACATCGTGTTGTCCGGTGGTACCACCATGTACCCTGGTATCTCGG
AACGTATGACCAAGGAATTGACCGCTTTGGCTCCTTCCACCATGAAGATCAAGGTTGTCG
CTCCTCCTGAGCGCAAGTACTCCGTCTGGATCGGTGGTTCAAGGGCGAATTC

>Botrytis cinerea consensus (actin confirmed)
GAATTCGCCCTTGTATGTGCAAGGCCGGTTTCGCCGGTGACGATGCTCCAAGAGCTGTTT
TCCGTAAGTAGATCATCCTTACAGGCAACTGTTGCAATCCACCACCTTGATTTCTATCAT
AATCAATCATCGACAACCACCTTGATGATAATGAAATATCTCTAACGTGCAATACAGCTT
CCATTGTCGGTCGTCCCCGTCATCATGGGTAAGAATTCCATTTCCACGACACCCCGCCAT
TTCCCCCACAACTCGTGTCACTCGAACAGGAACTGATAAGGGATTTTATAGTATTATGAT
TGGTATGGGTCAAAAGGACTCATATGTTGGAGATGAAGCGCAATCCAAGCGTGGTATTCT
TACCCTTAGATACCCAATCGAGCACGGTGTTGTCACCAACTGGGATGATATGGAGAAGAT
CTGGCATCACACTTTCTACAACGAACTTCGTGTAGCACCAGAGGAGCACCCAGTCTTACT
TACTGAGGCCCCAATCAACCCAAAGTCCAACAGAGAAAGATGACACAAATTGTCTTTGA
GACCTTCAACGCCCCTGCATTCTACGTCTCTATTCAAGCCGTCCTCTCCCTTTACGCTTC
CGGTCGTACCACCGGTATCGTTCTCGATTCCGGTGACGGAGTTACTCACGTTGTTCCAAT
TTACGAAGGTTTCTCTCTTCCTCACGCCATTGCTCGTGTTGACATGGCTGGTCGTGATTT
GACTGATTACCTCATGAAGATCTTGGCTGAGCGTGGTTACACTTTCTCCACCACTGCCGA
GCGTGAAATCGTCCGTGATATCAAGGAGAAGCTCTGTTATGTTGCTCTTGATTTCGAGCA
AGAAATCCAAACCGCCAGTCAATCCTCCAGCTTGGAGAAGTCATACGAACTTCCTGATGG
ACAAGTTATTACCATCGGTAACGAGCGTTTCCGTGCTCCAGAAGCTTTGTTCCAACCATC
TGTCTTGGGTCTTGAGAGCGGTGGTATCCACGTCACTACCTTCAACTCCATCATGAAGTG
TGATGTTGATGTCCGTAAGGATTTGTATGGTAACATTGTTATGGTAAGATTTCCCATCTG
CGAAGTTTACAGGACGATATGCTAACATTTTGACACAGTCTGGTGGAACCACTATGTACC
CAGGTATCTCCGATCGTATGCAAAAGGAAATCACTGCTCTTGCACCATCGTCGATGAAGG
TCAAGATCATTGCACCACCCGAGAGAAAATACTCCGTCTGGATCGGTGGTTCAAGGGCGA
ATTC

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>Fusarium oxysporum consensus (actin confirmed)
GAATTCGCCCTTGTATGTGCAAGGCCGGTTTCGCCGGTGATGATGCTCCCCGAGCTGTTT
TCCGTGAGTACCCCACTTTCTAGCCTCTGCGCCCAACGAATTGATATCGCATGTCCTGGG
CGCAAGTTAATCAGAAACCCAATTCTAACATTGTAAACAGCTTCCATTGTTGGTCGCCCC
CGTCATCATGGGTAAGTTGTAGCTACAGCGGCAATTCTGCCGCTTCCTTGGTGGCTGGCC
ACTGACAAGTTCTCAGTATCATGATTGGTATGGGTCAGAAGGACTCGTATGTTGgTGATG
AGGCTCAGTCCAAGCGTGGTATCCTCACTCTGCGATACCCCATTGAGCACGGTGTTGTCA
CCAACTGGGACGACATGGAGAAGATTTGGCACCACACCTTCTACAACGAGCTGCGTGTCG
CCCCCGAGGAGCACCCCGTCTTGCTCACCGAGGCTCCCATCAACCCCAAGTCCAACcGTG
AGAAGATGACCCAGATtGTCTTCGAGACATTTAACGCCCCAGCTTTCTACGTCTCCATCC
AGGCCGTTCTGTCTTTGTACGC-TCCGGTCGTACCACTGgTATCGTTCTGGACTCTGGTG
ATGGTGTCACTCACGTTGTCCCCATTTACGAGG-TTtcgCCcTtCCCCAcGCCATTGCCC
GTGTCGACATGGCTGGCCGTGATCTtACCGACTACCTCATGAAGATCCTTGCTGAGCGCG
GTTACACTTTCTCCACCACCGCCGAGCGAGAAATCGTCCGTGACATCAAGGAGAaGCTTT
GCTACGTCGCCCTCGACTTCGAGCAGGAGATCCAGACTGCCGCCCAGAGCTCCAGCCTGG
AGAAGTCCTACGAGCTTCCCGATGGTCAGGTCATTACTATTGGTAACGAGCGATTCCGTG
CTCCTGAGGCTCTCTTCCAGCCTTCTGTCCTtGGTCTTGAGAGCGGTGGTATCCATGTCA
CCACCTTCAACTCCATCATGAAGTGTGATGTCGATGTCCGAAAGGATCTCTACGGCAACA
TTGTCATGGTAaGTTTCGTGAGAATGAGCTGTCCAAATTTTTCTAACATTCATTCAGTCT
GGTGGTACCACCATGTACCCTGGTCTCTCCGACCGTATGCAGAAGGAGAtCACCGCCCTT
GCTCCTTcTTCCATGAAGGTCAAGATCATTGCTCCTCCCGAGCGAAAGTACTCCGTCTGG
ATCGGTGGTTCAAGGGCGAATTC

>Pythium aphidermatum consensus (actin confirmed)
GAATTCGCCCTTGTATGTGCAAGGCCGGTTTCGCCGGTGATGACGCCCCGCGCGCCGTCT
TCCCTTCCATCGTCGGTCGCCCAAAGCACCTCGGTATCATGGTCGGCATGGACCAGAAGG
ACGCGTACGTCGGTGACGAGGCGCAGAGCAAGCGTGGTGTGCTGACGCTCAAGTACCCAA
TCGAGCACGGTATTGTGACGAACTGGGACGACATGGAGAAGATCTGGCACCACACGTTCT
ACAACGAGCTTCGTGTGGCCCCAGAGGAGCACCCAGTGCTTCTGACGGAGGCTCCGCTCA
ACCCAAAGGCCAACCGTGAGCGTATGACGCAGATCATGTTCGAGACGTTTAACGTGCCAG
CCATGTACGTGAACATCCAGGCCGTGCTTTCG-TGTACGCTTCGGGTCGTACGACTGGTT
GCGTGCTCGACTCTGGTGATGGTGTCTCGCACACGGTGCCAATTTACGAGGGTTACGCTC
TTCCGCACGCCATCGTGCGTCTTGACCTTGCTGGTCGCGACCTCACGGACTACATGATGA
AGATCCTGACGGAGCGTGGTTACTCGTTCACGACGACGGCCGAGCGCGAAATTGTGCGTG
ACATCAAGGAGAAGCTCACGTACGTCGCCCTTGACTTCGACCAGGAGCTCAAGACCGCCG
CTGAGTCGTCGGGTCTCGAGAAGTCGTACGAGCTTCCTGACGGTAACGTCATTGTCATTG
GCAACGAGCGTTTCCGTACCCCAGAAGTGCTCTTCAACCCATCG-TGATCGGTAAGGAAG
CCAACGGTATCCACGACTGCACGTTCCAGACCATCATGAAGTGTGACGTCGATATCCGAA
AGGACCTGTACTGCAACATCGTGCTCTCGGGTGGTACCACCATGTACCCAGGCATTGGTG
AGCGTATGACCAAGGAGCTTACGGCCCTTGCCCCATCGACCATGAAGATCAAGGTCGTCG
CTCCACCAGAGCGTAAGTACTCCGTCTGGATCGGTGGTTCAAGGGCGAATTC

>Phoma betea consensus (actin confirmed)
GAATTCGCCCTTGTATGTGCAAGGCCGGTTTCGCCGGTGATGATGCGCCCCGTGCAGTCT
TCCGTAAGTCTTGCCCCCATCTCAGCGCCATCGCGAGAAGCCTCTTCTGACAGCTCTGCA
GCTTCCATTGTCGGCCGACCGCGCCACCATGGGTACGACCCTCCCCTAGTAGCTCCCTCC
CCCGAAGTCCCCCGAACTGACAACATGGTAGTATCATGATTGGTATGGGCCAGAAGGACT
CCTACGTCGGTGATGAGGCACAGTCGAAGCGTGGTATCCTGACTCTGCGATACCCCATTG
AGCACGGTGTTGTCACCAACTGGGACGACATGGAGAAGATCTGGCATCACACCTTCTACA
ACGAGCTGCGTGTTGCCCCCGAGGAGCACCCCGTCCTGCTCACCGAGGCTCCCATCAACC
CCAAGTCCAACCGTGAGAAGATGACGCAGATTGTCTTCGAGACCTTCAACGCCCCCGCCT
TCTACGTCTCCATTCAGGCCGTCCTGTCCCTGTACGCCTCTGGACGTACCACTGGTATCG
TCCTCGACTCCGGGACGGTGTCACTCACGTTGTCCCCATTTACGAGGTTTCGCCCTTCCC
CACGCCTTCCCGTGTCGACATGGCTGGTCGTGATCTGACTGACTACTTCATGAAGATCCT
GGCTGAGCGCGGTTACACCTTCTCCACCACTGCCGAGCGCGAAATCGTCCGTGACATCAA
GGAGAAGCTCTGCTACGTCGCTCTCGACTTCGAGCAGGAGATCCAGACTGCCAGCCAGTC
CTCCAGCTTGGAGAAGTCCTACGAGCTTCCCGACGGTCAGGTCATCACCATTGGCAACGA
GCGTTTCCGTGCTCCTGAGGCTCTCTTCCAGCCTTCCGTGCTCGGTCTTGAGAGCGGTGG
TATCCACGTCACCACTTTCAACTCCATCATGAAGTGCGATGTCGACGTCAGGAAAGACCT
GTACGGCAACATTGTCATGGTACGTTATACACTGCAGAAATCGGCGAGCGTCAATAGCTA
ACAATAACTAGTCTGGTGGTACCACCATGTACCCCGGTATCTCCGACCGTATGCAGAAGG

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AAATCACCGCCCTTGCCCCATCCTCGATGAAGGTCAAGATCATCGCTCCCCCCGAGCGCA
AGTACTCCGTCTGGATCGGTGGTTCAAGGGCGAATTC
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>Penicillium claviforme consensus (actin confirmed)
GAATTCGCCCTTGTATGTGCAAGGCCGGTTTCGCCGGTGACGACGCACCACGAGCTGTCT
TCCGTAAGTTCAACCCCACAGAATATGACACCCCTCCTTGCGAAGGCCGGCCATCCCACC
AACCCTTGCGTCGGATGGCTTCCCCTCTTTTGCTTGGCTGGGAAGAACCTTGAATCCGAG
AATAAAATCACTGACAAAATTCAACAGCCTCTATTGTCGGTCGTCCCCGTCACCATGGGT
AAATAATCCCCCCCCTTTTTTTGGCTCATTCTGGTCGTATACAACCATATACAACCAATT
TGATCCCCAATGAAGCAACCAAAAATACTAACATGCGCGCAGTATCATGATTGGTATGGG
TCA-AAGGACTCCTACGTTGGTGATGAGGCACAGTCCAAGCGTGGTATCCTCACGCTCCG
TTACCCCATTGAGCACGGTGTTGTCACCAACTGGGACGACATGGAGAAGATCTGGCACCA
CACCTTCTACAACGAGCTCCGTGTTGCCCCCGAAGAGCACCCCATTCTCTTGACCGAAGC
TCCCATCAACCCCAAGTCCAACGTGAGAAGATGACCAGATCGTGTTCGAGACTTTCAACG
CACCGCATTCTACGTCTCCATCCAGGCCGTTCTGTCCTGTACGCTCCGGTCGTACCACTG
GTATCGTTCTCGACTCCGGGACGGTGTCACCCACGTTGTCCCCATCTACGAGGGTTTCTT
CTGCCCCACGCTATCTCGCGTGTCGACATGGCTGGCCGTGATTTGACCGATTACCTGATG
AAGATCCTCGCTGAGCGTGGTTACACTTTCTCCACCACTGCCGAGCGTGAAATCGTCCGT
GACATCAAGGAGAAGCTTTGCTACGTCGCTCTCGACTTCGAGCAGGAGATCCAGACCGCT
TCCCAGAGCTCCAGCCTCGAGAAGTCCTACGAGCTTCCCGATGGACAGGTCATCACTATT
GGTAACGAGCGCTTCCGTGCTCCTGAGGCTCTCTTCCAGCCAAACGTTCTTGGCCTTGAG
TCTGGCGGTATCCACGTCACCACCTTCAACTCCATCATGAAGTGTGATGTTGATGTCCGT
AAGGATCTGTACGGCAACATTGTCATGGTAAGAAAAGCCTTTGGAATAAAACTTTGCGAA
ACTCCCACTAACACATACCTCTCTTTAGTCTGGTGGTACCACCATGTACCCCGGTATCTC
CGACCGTATGCAGAAGGAGATCACTGCTCTTGCTCCTTCTTCCATGAAGGTCAAGATCAT
CGCTCCCCCCGAGCGCAAGTACTCCGTCTGGATCGGTGGTTCAAGGGCGAATTC
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Figure 1. Actin-coding gene sequences from fungal pathogens of sugarbeet. The gene sequence have not been examined for the presence of intron sequences, but have been confirmed to encode amino acid sequences with actin homology. The underlined *Eco*R1 site (GAATTC) indicates the insertion site of the sequence in the cloning vector.

Finally, in 2003, anti-Aphanomyces antisera was produced in rabbits that shows high affinity for *A. cochlioides* (Figure 2). Although the antiserum also cross-reacts with *A. euteiches*, the reactivity with other sugarbeet seedlings and root pathogens (i.e. *Rhizoctonia solani* AG2-2 and AG4, *Pythium ultimum*, *Pythium aphanidermatum*, and *Phoma betae* is low (not shown). This will be used to compare enzyme linked immunosorbant assay (ELISA) with real-time PCR in testing the limits of detection of *A. cochlioides* between the two techniques. Use of real-time PCR in the evaluation of alfalfa varieties with resistance to *Aphanomyces euteiches* has proven to be as accurate as visual rating (Quantifying *Aphanomyces euteiches* in Alfalfa with a Fluorescent Polymerase Chain Reaction Assay. G. J. Vandemark, B. M. Barker, and M. A. Gritsenko. 2002. Phytopathology 92:265-271).

Additionally the antiserum will be useful in localization of *A. cochlioides* in sugarbeet root tissue using immunohistochemical techniques. Moreover, the characterization of the protein constituants of the hyphae of *A. cochlioides*, potential targets for anti-biotic design, will be accelerated by the use of this antiserum. Aliquots of the antiserum will be made available to public and private laboratories upon request.
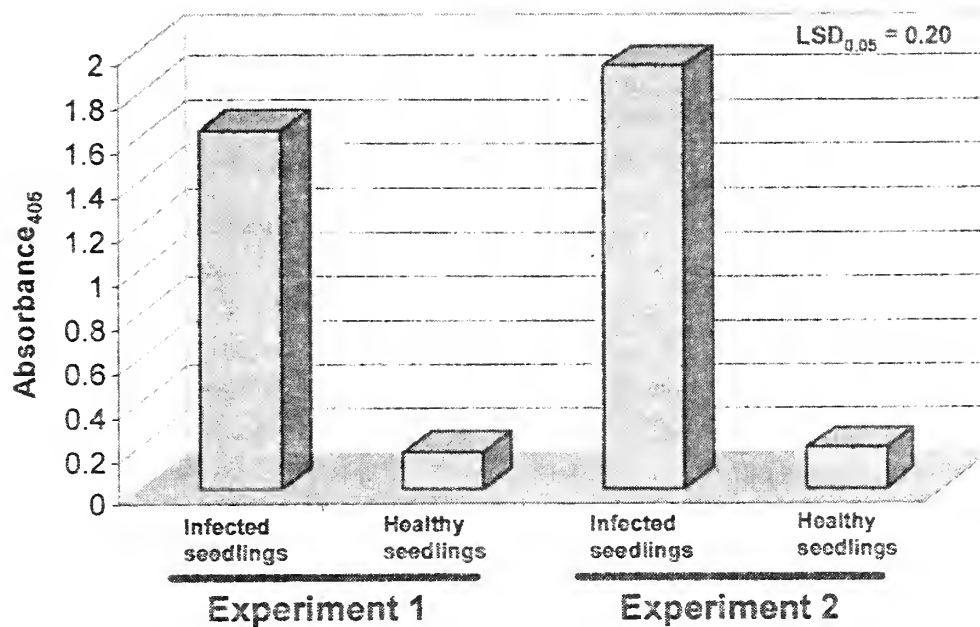
Figure 2. Detection of *A.cochlioides* in infected sugarbeet seedlings using *anti-A. cochlioides* antiserum and the ELISA system. The results of two independent experiments are shown. A higher absorbance indicates presence of immunoreactive material in the seedling extract.

MECHANISMS OF RESISTANCE IN SUGARBEET TO FUNGAL AND BACTERIAL PATHOGENS
Project 621

John J. Weiland

Enzymes and enzyme inhibitors that accumulate in sugarbeet that is under pathogen stress often are associated with resisting pathogen invasion. Some of these activities are produced to strengthen natural barriers in the plant to pathogen invasion. Others are produces as an arsenal of compounds toxic to the pathogen or as inhibitors of phytotoxins produced by the pathogen. Identification of sugarbeet enzymes, and their corresponding genes, produced in defense against pathogens can further our understanding of the basis for disease resistance. Such knowledge can be used in the selection of germplasm with enhanced pathogen resistance. In addition, the cloning of the genes for defense-related enzymes and inhibitors can lead toward the production of genetically modified (engineered) germplasm for use in sugarbeet breeding programs.

Protease activity secreted into the culture media by *A. cochlioides* is being investigated as a virulence component in the production of disease in sugarbeet. Proteases are produced in abundance by Aphanomyces species, including those that infect fish and crayfish. Previously in our lab, it was shown that a proteinase inhibitor from lima bean effectively inhibits a subset of the proteases that are separable using gel electrophoresis. In 2003 we prepared cDNA libraries from *A. cochlioides* cultured in rich media, starvation media, sterile beet root slices in water, and in infected seedlings. From these libraries we are beginning to isolate protease gene sequences (Figure 1). We are augmenting these studies with efforts to identify protease inhibitors in sugarbeet varieties exhibiting increased resistance to *A. cochlioides*.
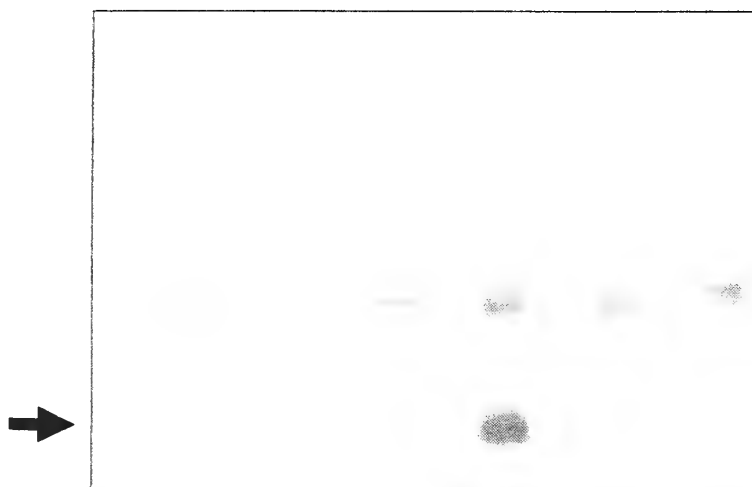
Figure 1. Southern blot of clones picked from cDNA library of *A. cochlioides*. The probe for the blot was a sequence (0.4 kb) amplified from the *A. cochlioides* genome encoding a product with homology to a trypsin-like protease from *A. astaci*. The arrow indicates a clone with a ~1.2 kbp insert which is hybridizing to the probe.

Also in 2003, we obtained, in collaboration with Dr. Kuang-Ren Chung at the University of Florida, mutants of *Cercospora beticola* that lack cercosporin production. These mutants were generated by disruption of a polyketide synthase gene already known to be required for cercosporin biosynthesis in *C. kikuchii* and *C. nicotianae*. These mutants (see Figure 2) will be inoculated to sugarbeet plants in controlled settings to ascertain the contribution of cercosporin production on virulence of this pathogen. In addition, these mutants will be examined for the production of the beticolin toxins which may or may not be made by the same biosynthetic pathway. These investigations will yield important information regarding the targets for breeding research efforts as well as indicating targets for the control of *C. beticola* by biotechnological means.
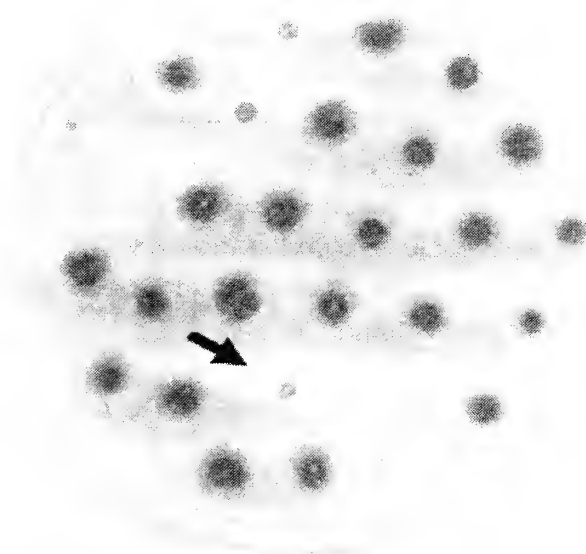
Figure 2. Candidate disruption mutants in the cercosporin biosynthetic pathway of *C. beticola*. A mutated polyketide synthase gene fragment was used to distrupt the gene by site-directed mutagenesis. The arrow indicates a candidate on this particular plate.

TAGGING OF GENES FOR DISEASE RESISTANCE IN SUGARBEET USING MOLECULAR GENETIC MARKERS
Project 622

John J. Weiland

Markers that tag regions of chromosomes that harbor genes contributing to disease resistance in sugarbeet can be of use in many aspects of research. Such landmarks on the genomic map can be used in marker-assisted selection in sugarbeet breeding programs. In addition the markers can provide information regarding the clustering or lack thereof regarding the distribution of resistance genes throughout the genome. Finally, chromosome markers can be integral tools in the identification of DNA clones that potentially harbor resistance gene sequences. Cloned resistance genes can be analyzed for clues as to their mode of action and can be transferred between plant species using gene transfer technologies.

We have focused early efforts on the tagging of resistance to powdery mildew disease and to root knot nematode. Similar work has already been done in European laboratories the analysis of resistance to Cercospora leaf spot and Rhizomania diseases. Powdery mildew (*Erysiphe polygoni*) and root knot nematode (*Meloidogyne* spp) resistance in sugarbeet has recently been characterized by ARS colleagues in Salinas, CA. Both genes show promise for the genetic control of several races of the organisms causing these diseases. In collaboration with Drs. Robert Lewellen (ARS-Salinas) and J. Mitch McGrath (ARS-East Lansing), these resistance genes are being tagged using the random amplified polymorphism (RAPD) technique.

In 2003, a sequence characterized amplified region (SCAR) marker was obtained from our previous mapping project that is associated with resistance to beet mosaic virus (BMV; Figure 1). This marker is being used to characterize three separate populations segregating for resistance to BMV (1221-2-2, 1221-3-2, and 1221-4-2) provided by Dr. Robert Lewellen and the USDA-ARS in Salinas, CA. Each population has had the *Bm* gene for resistance to BMV introgressed into them by standard breeding practices.

In efforts to produce more robust markers for the *Pm* gene conferring resistance to powdery mildew disease, advanced populations provided by Dr. Lewellen are being screened in the greenhouse at Fargo. These results from these screens will be used to evaluate markers for tight linkage to the *Pm* gene. These will be converted to SCAR markers as we have done for the genes conferring resistance to root knot nematode and beet mosaic virus.

Finally, studies on the segregation of resistance to *A. cochlioides* has moved more slowly than anticipated due to the variable reaction of segregants to the disease. Additional refinements will be made to the inoculation and rating protocols, which will employ the detection and quantitation schemes for *A. cochlioides* outlined in Project 620.

140 plants tot.; 111 resistant, 29 susceptible, $X^2 = 1.37$, P = 0.242
F2 population 1221-2-2 from R. T. Lewellen, USDA-ARS, Salinas, CA
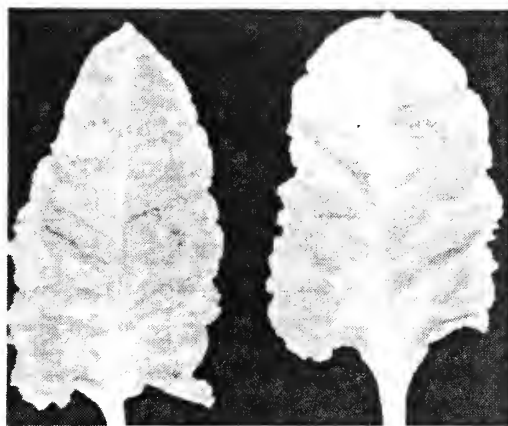
Without *Bm*
resistance gene

With *Bm*
resistance gene

Figure 1 **Inheritance of resistance to beet mosaic virus (BMV) in sugarbeet. Inoculations were carried on in a greenhouse at the USDA-ARS-Fargo laboratory and rated for disease at 18 days post-inoculation.**

BMV resistant   BMV susceptible
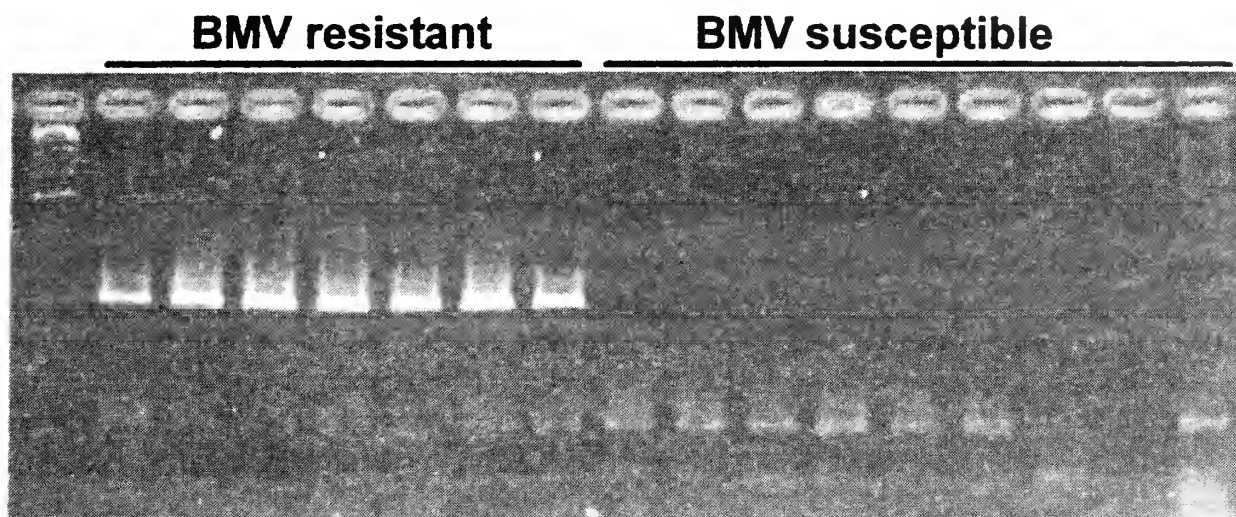
Figure 2.   SCAR marker for resistance to BMV. Primers Rbm06fwd and Rbm06rev were used to prime PCR reactions using genomic DNA of sugarbeet. Products were fractionated on a 1.5% agarose gel. Each lane represents an individual plant from population 1221-2-2. Marker is ~0.5 kbp in size and is highly associated with the resistance-conferring allele.

ROLE OF SUCROSE METABOLIZING ENZYMES IN SUGARBEET ROOT GROWTH, CARBOHYDRATE PARTITIONING AND POSTHARVEST SUCROSE LOSS
Project 650

Karen Klotz

Sucrose catabolism has been implicated as a major factor controlling whole plant carbon partitioning, root growth, sucrose accumulation, and postharvest sucrose loss (Wyse, 1974; Giaquinta, 1979; Sung *et al.*, 1989; Berghall *et al.*, 1997; Klotz & Finger, 2002). Three enzyme activities, sucrose synthase, acid invertase, and alkaline invertase, contribute to sucrose catabolism in sugarbeet root. Sucrose synthase, a cytoplasmic enzyme, catalyzes the conversion of sucrose to fructose and UDP-glucose, a metabolically activated form of glucose. Acid invertase catalyzes the hydrolysis of sucrose to fructose and glucose, and occurs as a soluble enzyme in the vacuole or as an insoluble enzyme in the cell wall. Alkaline invertase catalyzes the same sucrose hydrolysis reaction as acid invertase, but is located in the cytoplasm and exhibits activity at higher pH values.

Research over the life of this project has examined the contribution of the three sucrolytic activities to sucrose catabolism during development and postharvest storage. These studies identified sucrose synthase as the principle sucrose degrading activity during production and storage, and suggested possible roles for this activity in the regulation of carbohydrate partitioning to the root and cell wall biosynthesis during root production, and sucrose loss during postharvest storage. Research over the past twelve months has been directed toward two goals: (1) to determine the impact of storage disease on sugarbeet root sucrolytic activities, and (2) to determine the genetic, physiological and environmental factors that regulate sucrose synthase expression.

Impact of storage disease on sugarbeet sucrolytic activities. The development of storage diseases is associated with significant increases in sucrose loss and invert sugar accumulation (Mumford and Wyse, 1976; Wyse, 1978). The increase in sucrose degradation may be due to sucrolytic activities originating from the pathogen or endogenous sucrolytic activities induced in response to disease. Sucrolytic activities and carbohydrate concentrations were determined in stored roots before and after the development of disease symptoms. Field grown roots stored at 6°C and 96 to 99% relatively humidity exhibited no visible symptoms of disease at harvest or after four weeks in storage, but were severely rotted after 20 weeks in storage. The causal agents for the rot were *Penicillium spp.* and *Botrytis cinerea* based on visual symptoms. A comparison of carbohydrate concentrations after four and 20 weeks in storage, i.e., before and after the development of visible disease symptoms, revealed a significant increase in invert sugar concentration in rotted roots (Table 1A). Glucose and fructose concentrations were three and 19-fold greater in rotted roots than in roots exhibiting no disease symptoms. Sucrose concentration was 18% lower in rotted roots, although this decline was not statistically significant. Sucrose synthase and alkaline invertase activities were not significantly different between asymptomatic and severely rotted roots (Table 1B). Soluble acid invertase activity, however, was elevated by more than 650%, and insoluble acid invertase activity was reduced by 82% in rotted roots compared to asymptomatic roots.

Table 1: Change in carbohydrate concentrations (A), and sucrolytic enzyme activities (B) in sugarbeet roots before (4 weeks) and after (20 weeks) the development of visible symptoms of storage rots. Carbohydrate concentrations are expressed in mmole $\cdot$ g potassium^{-1}. Sucrose synthase activity, alkaline invertase activity, and soluble acid invertase activity are expressed as µmoles sucrose cleaved $\cdot$ g protein^{-1} $\cdot$ min^{-1}. Insoluble acid invertase activity is expressed as nmole sucrose cleaved $\cdot$ g dry mass of insoluble cell materials^{-1} $\cdot$ min^{-1}. Data are the mean $\pm$ 1 standard error of the mean (n = 4). Representative sections from 8 to 10 roots were combined to create each replicate. Significant differences ($P \leq 0.05$) are noted by an asterisk following the percent change in activity.

A.

Carbohydrate conc. (mmol·g^{-1})	storage duration (weeks)		change in activity (%)
	4	20	
glucose	2.10 ± 0.29	8.32 ± 2.18	295 *
fructose	0.63 ± 0.25	12.6 ± 2.9	1920 *
sucrose	195 ± 13	160 ± 16	- 18

B.

Sucrolytic activity	storage duration (weeks)		change in activity (%)
	4	20	
sucrose synthase (µmol·g^{-1}·min^{-1})	185 ± 12	210 ± 57	14
alkaline invertase (µmol·g^{-1}·min^{-1})	7.9 ± 0.5	7.3 ± 1.7	- 8.2
soluble acid invertase (µmol·g^{-1}·min^{-1})	8.6 ± 0.2	65 ± 19	654 *
insoluble acid invertase (nmol·g^{-1}·min^{-1})	71 ± 23	13 ± 8	- 82 *

The increase in soluble acid invertase activity was due primarily to fungal acid invertases. Acid invertase isoforms were separated by isoelectric focusing polyacrylamide gel electrophoresis and identified by activity staining of gels (Figure 1). Protein extracts from severely rotted roots and fungi cultured *in vitro* from rotted roots contained acid invertase isoforms with isoelectric points between 3.3 and 3.6. In contrast, endogenous sugarbeet acid invertase had an isoelectric point of 4.7. Young root tissue was used to identify the pI of sugarbeet invertase, since acid invertase activity is greatest in young tissue. No acid invertase isoforms were above the limits of detection in roots prior to the development of storage rots. Prolonged activity staining of the gel revealed a trace of the endogenous sugarbeet acid invertase isoform, with a pI of 4.7, in protein extracts from severely rotted roots (data not shown).
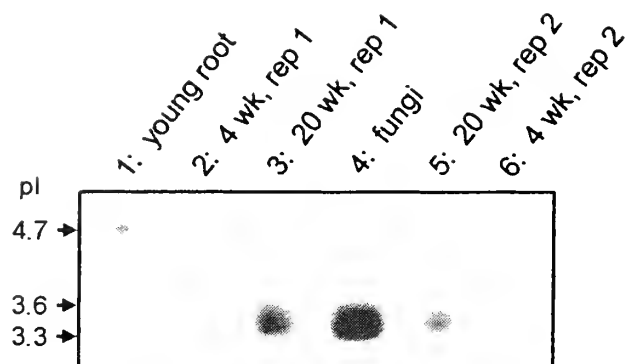
Figure 1: Soluble acid invertase isozymes in roots with no disease symptoms and roots exhibiting severe storage rot. Invertase isozymes were separated by isoelectric focusing polyacrylamide gel electrophoresis and detected by activity staining. Protein extracts from young sugarbeet root, harvested four weeks after planting, and fungi, cultured from diseased roots, were included to identify the isoelectric points of endogenous sugarbeet enzyme and fungal enzymes, respectively. Lane 1, soluble protein extract from sugarbeet root four weeks after planting (65 µg); lanes 2 and 6, soluble protein extracts from two independent replicates of asymptomatic roots after four weeks in storage at 6° C (45 µg); lanes 3 and 5, soluble protein extracts from two independent replicates of roots exhibiting symptoms of severe storage rots after 20 weeks in storage at 6° C (45 µg); lane 4, soluble protein extract from fungi cultured from roots exhibiting storage rots (9.2 µg).

The results suggest that reducing the sucrose loss and invert sugar accumulation that occurs in rotted roots may only be achieved by reducing the incidence and severity of disease, since the enzymes responsible for sucrose degradation are primarily of fungal origin. The unchanging activity of sucrose synthase activity in this and previous postharvest studies, coupled with the central role of this enzyme in postharvest sucrose catabolism, also suggests that a reduction in storage sucrose loss may best be achieved by minimizing sucrose synthase activity at time of harvest.

Regulation of sucrose synthase expression by genetic, physiological, and environmental factors.
Although sucrose synthase is the principle sucrose degrading activity during production and storage, the genetic, physiological and environmental factors that influence its activity are generally unknown. Research was initiated during the past twelve months to investigate these factors. Previous research indicated that two isoforms contribute to sucrose synthase activity in sugarbeet root (Klotz and Finger, 2002). It was likely that these isoforms originated from two sucrose synthase genes, since two or more sucrose synthase genes are typically found in most plant species. The isolation and cloning of a sugarbeet sucrose synthase gene, SBSS1, were reported in 1996 (GenBank ascension: X81974; Hesse and Willmitzer, 1996). A second sugarbeet sucrose synthase gene, SBSS2, was identified and sequenced last year (GenBank ascension: AY457173). The gene was initially identified as an EST from a salt stressed seedling cDNA library by Dr. Mitch McGrath. SBSS1 encodes a protein of 822 amino acid residues; SBSS2 encodes a protein of 806 amino acid residues. The two genes are 61.6% identical in their nucleotide sequence, and 69.1% identical and 79.7% similar in the sequence of their encoded proteins.
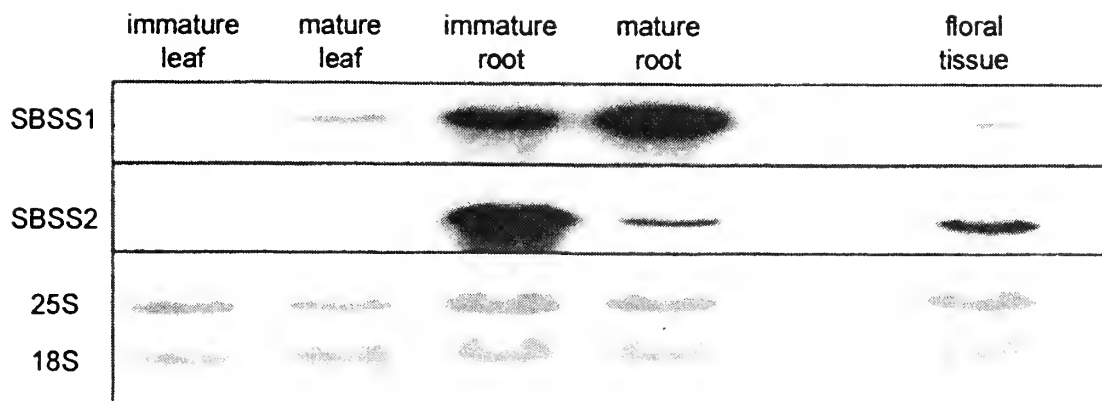
Figure 2: Tissue specificity of SBSS1 and SBSS2 expression. Total RNA (10 μg) was glyoxal treated and separated on a 1% agarose gel, transferred to a nylon membrane and probed with a 1181 bp fragment from SBSS1 or a 1283 bp fragment of SBSS2. Ribosomal RNA was visualized on the membrane with methylene blue.
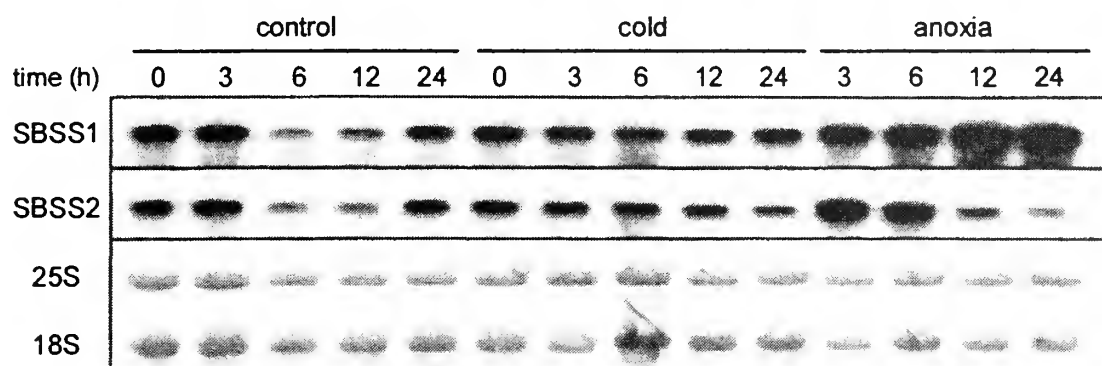
Figure 3: Response of SBSS1 and SBSS2 expression to cold and anoxia. Treated plants were incubated at 4°C or submerged to the top of top of the crown. All plants were kept on a 16 h day/8 h night cycle prior to and during experiment. Plants for the control and anoxia treatments were maintained in a 24 to 27°C greenhouse. Total RNA (10 μg) was glyoxal treated and separated on a 1% agarose gel, transferred to a nylon membrane and probed with a 1181 bp fragment from SBSS1 or a 1283 bp fragment of SBSS2. Ribosomal RNA was visualized on the membrane with methylene blue.

Both SBSS1 and SBSS2 are expressed to high levels in root tissue and to low levels in leaf tissue (Figure 2). Expression of the two genes is developmentally controlled, with SBSS2 expressed at greater levels in immature tissues and SBSS1 expressed at greater levels in mature tissues.

Steady state transcript levels of SBSS1 and SBSS2 exhibit diurnal changes. Transcript levels in root tissue harvested from greenhouse grown plants over a 24 h time period that began at the initiation of a 16 h day/8 h night cycle were greatest at the beginning and three hours into the light period (Figure 3, control). Lowest transcript levels were observed six hours into the light period. At 4°C, SBSS1 and SBSS2 did not exhibit diurnal changes in transcript level (Figure 3, cold). Transcript levels of both genes were relatively unchanged throughout the 24 h of the cold treatment, although
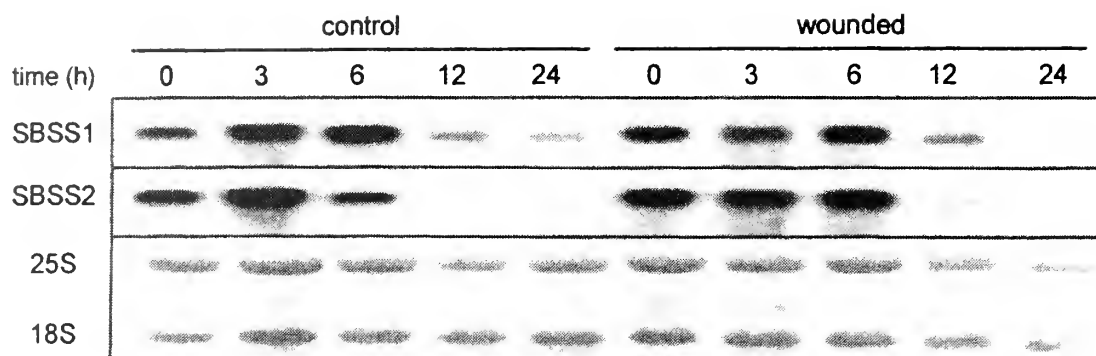
Figure 4: Response of SBSS1 and SBSS2 expression to wounding. All roots were harvested and incubated at 20°C for 24 h. Wounded roots were severely bruised by tumbling in a pilot lab beet washer. RNA was extracted from bruised tissue and tissue from a comparable location on control roots. Total RNA (10 μg) was glyoxal treated and separated on a 1% agarose gel, transferred to a nylon membrane and probed with a 1181 bp fragment from SBSS1 or a 1283 bp fragment of SBSS2. Ribosomal RNA was visualized on the membrane with methylene blue.

a slight decline in SBSS2 transcript level was observed after 24 h. Anaerobic conditions induced SBSS1 transcript levels (Figure 3, anoxia). SBSS2 transcripts were elevated three and six hours into the anaerobic treatment, but declined after roots were submerged for 12 and 24 hours.

Similar transcript levels of SBSS1 and SBSS2 were observed in wounded and unwounded roots in the 24 h after harvest and administration of the wound treatment. Transcripts of both genes declined in all roots twelve hours after harvest. Presently it is unknown whether this decline was a wound response, since harvesting was associated with some injury in all roots, due to shoot removal, or due to some other factor.

Research to date regarding the regulation of sucrose synthase expression is preliminary. Although changes in transcript level in response to a diurnal cycle, anaerobic conditions, and harvest have been observed, the duration of these responses and their impact on sucrose synthase protein level and activity are unknown. These questions, as well as the regulation of sucrose synthase activity in response to nutrition, carbohydrate content, and plant development, will be examined in the coming year. The goal of these studies is to determine the impact of genetic factors and cultural and storage practices on sucrose synthase activity and to elucidate mechanisms by which sucrose synthase activity may be altered to maximize yield and minimize sucrose loss during production and storage.

Conclusions

➤ The enzymes responsible for sucrose loss and invert sugar accumulation in roots with storage rots are primarily of fungal origin. Reducing sugar loss and invert sugar accumulation due to the development of storage rots, therefore, may only be achieved by reducing the incidence and severity of disease.

➤ Sucrose synthase, the predominant sucrolytic activity in postharvest sugarbeet roots, is unaffected by storage rot. Previous research indicates that its activity is generally unaffected by storage temperature or length of storage. The unchanging activity of this enzyme during storage suggests that a reduction in sucrose loss due to this enzyme may best be achieved by minimizing sucrose synthase activity at time of harvest. Research is ongoing to determine the genetic and environmental factors that influence its expression during production.

➤ Two sucrose synthase genes contribute to sucrose synthase expression. The genes differ in their expression due to developmental cues and in response to anaerobic conditions. Transcription of both genes was impacted by harvest, but not by exposure to cold nonfreezing temperatures. Future research will determine the impact of these transcriptional changes on sucrose synthase activity, and examine the impact of nutrition, carbohydrate content, and plant development on sucrose synthase expression and activity.

References

Berghall, S., Briggs, S., Elsegood, S.E., Eronen, L., Kuusisto, J.O., Philip, E.J., Theobald, T.C., and Walliander, P. (1997). The role of sugar beet invertase and related enzymes during growth, storage and processing. *Zuckerind.* **122**, 520-530.

Giaquinta, R.L. (1979). Sucrose translocation and storage in the sugar beet. *Plant Physiol.* **63**, 828-832.

Hesse, H., and Willmitzer, L. (1996). Expression analysis of a sucrose synthase gene from sugar beet (*Beta vulgaris* L.). *Plant Mol. Biol.* **30**, 863-872.

Klotz, K.L., and Finger, R.L. (2002). Contribution of invertase and sucrose synthase isoforms to sucrose catabolism in developing sugarbeet roots. *J. Sugar Beet Res.* **39**, 1-24.

Mumford, D.L., and Wyse, R.E. (1976). Effect of fungus infection on respiration and reducing sugar accumulation of sugarbeet roots and use of fungicides to reduce infection. *J. Amer. Soc. Sugar Beet Technol.* **19**, 157-162.

Sung, S., Xu, D., and Black, C. (1989). Identification of actively filling sucrose sinks. *Plant Physiol.* **89**, 1117-1121.

Wyse, R. (1974). Enzymes involved in the postharvest degradation of sucrose in *Beta vulgaris* L. root tissue. *Plant Physiol.* **53**, 507-508.

Wyse, R. (1978). Effect of harvest injury on respiration and sucrose loss in sugarbeet roots during storage. *J. Amer. Soc. Sugar Beet Technol.* **20**, 193-202.

CHARACTERIZATION OF RESPIRATORY PROCESSES IN SUGARBEET ROOTS DURING POSTHARVEST STORAGE
Project 660

Karen L. Klotz

Respiration is the oxidative process that converts cellular carbon compounds to carbon dioxide and water, providing substrates and energy for biochemical synthesis and maintenance of plant cells. In sugarbeet roots, sucrose is the primary substrate for respiration and it is estimated that 80% of the sucrose lost during postharvest storage under favorable conditions is used to fuel respiration (Wyse and Dexter, 1971). Respiration is required to maintain healthy tissue during storage, heal wounds acquired during harvest and defend against storage pathogens. The actual respiratory requirements of sugarbeet roots, however, are unknown, although the identification of sugarbeet lines with reduced respiratory rates suggests that a reduction in postharvest respiration is possible (Theurer *et al.*, 1978; Wyse *et al.*, 1978). Respiration in plants is regulated by the availability of respiratory substrates, the capacity of respiratory pathways, or cellular energy status, and is influenced by environmental and physiological conditions including storage temperature, oxygen and carbon dioxide concentrations, injury, and disease. The mechanism of regulation and the influence of environmental and physiological effectors on sugarbeet postharvest respiration, however, is largely unexplored.

Research conducted under this project seeks to determine the metabolic mechanism controlling sugarbeet respiration and the impact of environmental conditions and physiological stress on respiration rate. Sugarbeet roots are subjected to conditions and stresses expected to alter respiration to determine (1) the magnitude and duration of respiratory change caused by these effectors, and (2) the metabolic changes that occur in roots due to these treatments in relation to changes in respiration rate. The purpose of these studies is twofold: (1) to quantify the impact of individual environmental and physiological stresses and (2) to identify metabolites, enzymes, or pathways that may regulate sugarbeet respiration rate. The potential regulators identified in these studies will be the subject of future research to establish their role in the control of sugarbeet respiration. The goal of this project is to provide information that can be used to evaluate the impact of cultural and storage practices on postharvest respiratory sucrose loss and to guide efforts to genetically select or modify sugarbeets for reduced respiration rates.

In research reported last year, sugarbeet root respiration and the capacity of respiratory pathways were determined in response to wounding, storage temperature and length of storage (Klotz and Anderson, 2003). Total respiratory capacity and the capacities of the two pathways that contribute to total respiratory capacity, i.e., the cytochrome *c* oxidase and the alternative oxidase pathways, were determined in wounded and unwounded roots stored at 10 and 1°C. A major finding from this study was that respiration rate was unrelated to respiratory capacity. Although changes in respiration rate, total respiratory capacity, and the capacities of the cytochrome *c* oxidase and alternative oxidase pathways occurred in response to wounding, storage temperature and length of storage, no relationship between respiration rate and total respiratory capacity, or the capacity of the cytochrome *c* or the alternative oxidase pathway was observed. The implication of this observation is that sugarbeet respiration is likely to be regulated by substrate availability or cellular energy status.

Research during the past 12 months examined the possible regulation of respiration by substrate availability and cellular energy status. Because respiration is a multi-step process involving sucrolysis, glycolysis, the tricarboxylic acid cycle, electron transport and oxidative phosphorylation, several substrates are required for its occurrence (Figure 1). Possible substrates that may be limiting respiration are oxygen, ADP and carbon substrates, where carbon substrate availability is determined by the flux of carbon compounds through sucrolysis, glycolysis and the tricarboxylic acid (TCA) cycle. The product of respiration is cellular energy in the form ATP. Cellular energy status is often indicated by the ratio of ATP to ADP, that is, the ratio of product to substrate for oxidative phosphorylation, the final step in the respiratory process.

The concentration of ADP and the ratio of ATP to ADP were determined in wounded and unwounded roots during seven days storage at 10° and 1°C (Figure 2). ADP concentrations generally increased during storage regardless of storage temperature or wounding. ADP, a substrate for oxidative phosphorylation, can limit respiration if present in insufficient quantities. If limiting, an increase in ADP concentration would be expected to precede a rise in respiration rate. In this study, however, ADP concentration was generally unrelated to respiration rate. The ratio of ATP to ADP generally declined during storage in all roots. At 10°C, the decline in ATP:ADP was greater in unwounded control roots than in wounded roots. At 1°C, the decline in ATP:ADP was transient and similar for both wounded and unwounded roots. If cellular energy status is regulating respiration, a decline in the ATP to ADP ratio would be expected prior to a rise in respiration. No relationship between respiration rate and the ATP:ADP ratio was apparent in this study.

sucrose

sucrolysis ↓ 3 enzymes

monosaccharides

glycolysis ↓ 10+ enzymes

pyruvate

TCA cycle ↓ 9 enzymes

CO$_2$ + NADH, FADH$_2$

e⁻ transport ↓ O_2 + ADP

oxidative
phosphorylation ↓

ATP + H$_2$O
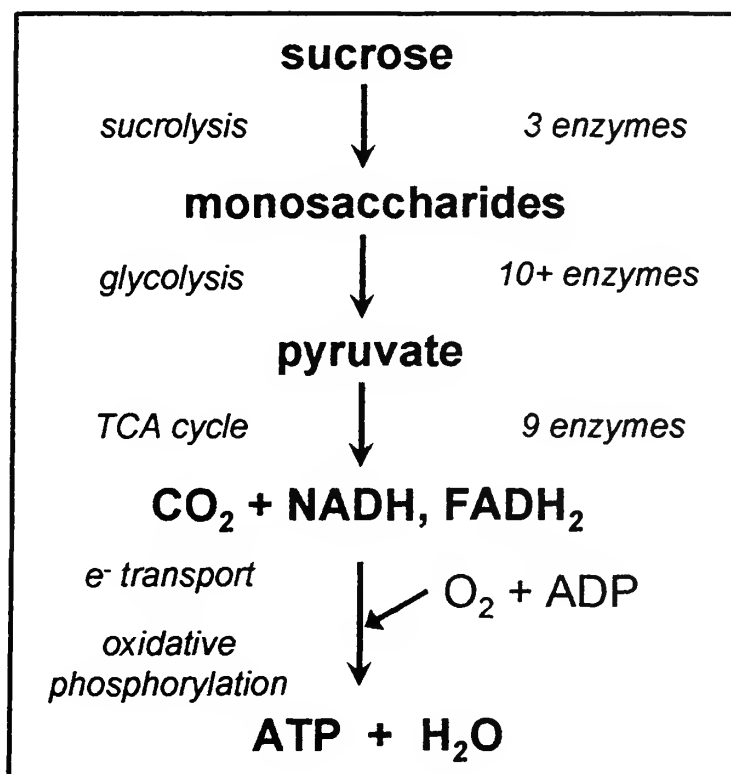
Figure 1: Simplified schematic of the sucrose respiratory pathway.
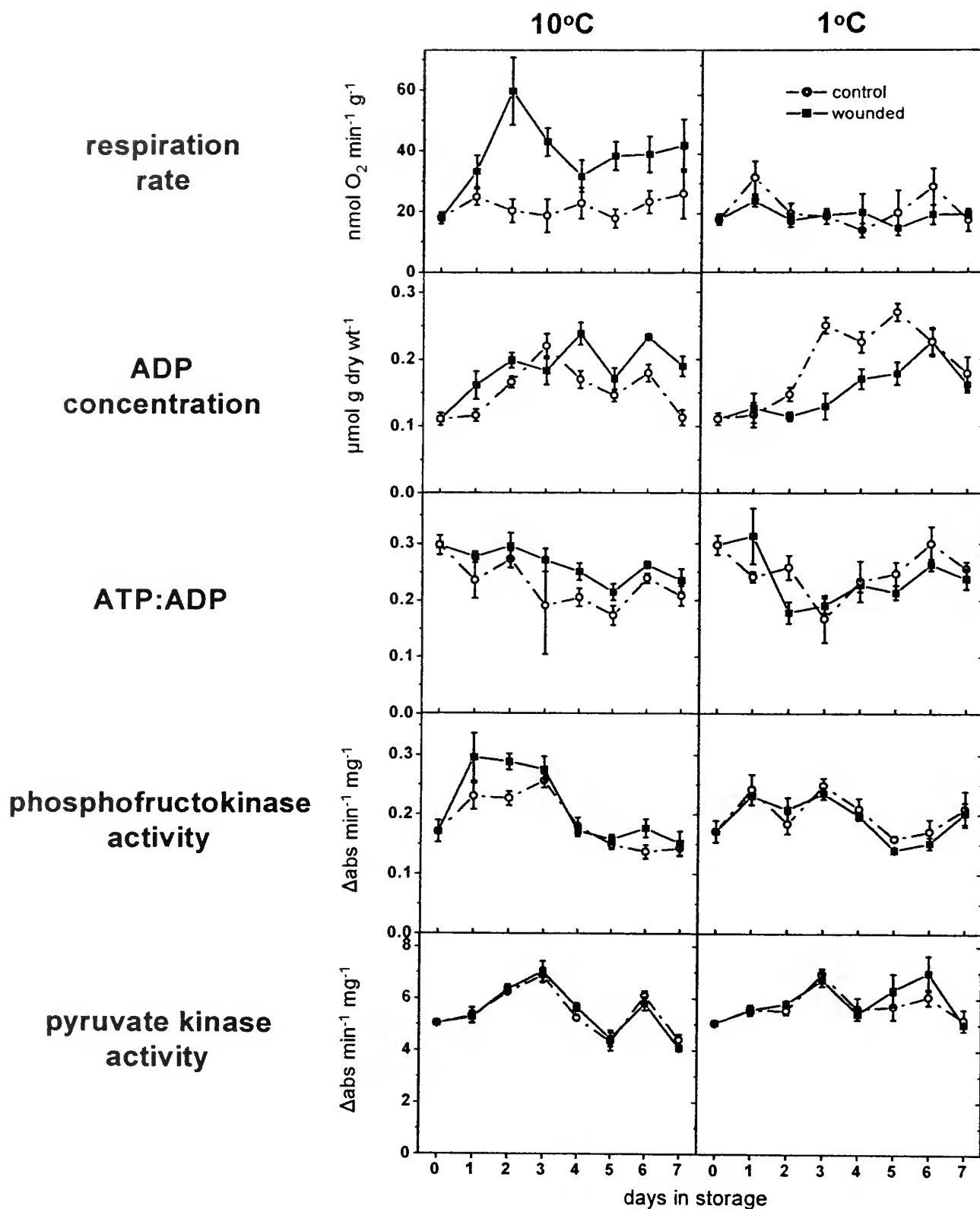
Figure 2: Respiration rate, ADP concentration, ATP:ADP ratio and the activity of the glycolytic enzymes, phosphofructokinase and pyruvate kinase, during storage of wounded and unwounded roots at 10° and 1°C.

To confirm that respiration rate was unrelated to ADP concentration or the ratio of ATP to ADP, respiration of tissue sections was determined before and after the addition of an uncoupler of respiration. Uncouplers separate oxidative phosphorylation from the rest of the respiratory pathway and respiration occurs without ATP production. In uncoupled respiration, ADP concentration and the ATP:ADP ratio can no longer regulate respiration, and an increase in respiration would occur if either ADP concentration or ATP:ADP is limiting. Addition of the uncoupler, carbonyl cyanide 3-chlorophenylhydrazone (CCCP), to root tissue sections caused no increase in respiration. The results of our research agree with the conclusions of Shugaev and Bukhov (1997) who investigated respiratory control during sugarbeet root development. No relationship between respiration rate and ADP concentration or the ratio of ATP to ADP was observed during sugarbeet production. These authors, however, noted a 50% increase in respiration rate in the presence of uncouplers. Despite this latter observation, Shugaev and Bukhov concluded that adenylate concentrations do not control sugarbeet respiration during root development.

Carbon substrate availability is determined by the flux of carbon compounds through sucrolysis, glycolysis and the TCA cycle, and respiration can be limited by a restriction in any reaction in these pathways. Although more than 22 enzymes can participate in the degradation of sucrose to carbon dioxide, not all enzymes are equal in their likelihood to be regulatory. The activities of the three enzymes that contribute to sucrolysis and two glycolytic enzymes were determined. The two glycolytic enzymes examined, phosphofructokinase and pyruvate kinase, have been implicated in the control of carbon flow through glycolysis in other plant species. No activities of TCA cycle enzymes were determined since the TCA cycle is not generally believed to be limiting. The activities of the three sucrolytic enzymes, sucrose synthase, alkaline invertase and acid invertase, were determined and presented in last year's report (Klotz, 2003). No relationship between the activity of any of these enzymes and respiration rate was observed. Phosphofructokinase, the first committed enzyme in glycolysis, exhibited elevated activity in wounded and unwounded roots at both storage temperatures (Figure 2). The increase in phosphofructokinase activity was greatest in wounded roots at 10°C and preceded a threefold increase in respiration rate. Pyruvate kinase, the last committed enzyme of the glycolytic pathway, exhibited similar activities in wounded and unwounded roots at both storage temperatures. Generally, pyruvate kinase activity transiently increased during the second and third day in storage at both temperatures. At 1°C, pyruvate kinase activity was also elevated during the fifth and sixth day in storage.

The increase in phosphofructokinase activity that preceded the increase in respiration in wounded roots stored at 10°C suggested that the role of this enzyme in respiratory control warranted further study. Clearly, phosphofructokinase is not solely responsible for respiratory control, since changes in its activity were unassociated with changes in respiration rate in unwounded roots stored at 10° and 1°C and in wounded roots stored at 1°C. Respiration was measured in tissue sections before and after the addition of inorganic phosphate, a known activator of phosphofructokinase activity (Table 1). The addition of phosphate increased the respiration rate of root tissue by 2.6 fold. Addition of fructose 6-phosphate, a substrate for phosphofructokinase reaction, to the phosphate-stimulated tissue increased respiration by an additional 35%.

Table 1: Change in root respiration rate after addition of inorganic phosphate and fructose 6-phosphate.

	respiration rate (normalized)
tissue	1.0 ± 0.1
tissue + P_i	2.6 ± 0.3
tissue + P_i + F6P	3.5 ± 0.4

Conclusions

➤ Respiration rate was unrelated to respiratory capacity, ADP concentration or cellular energy status in wounded and unwounded roots stored at 10° and 1°C, suggesting that substrate availability may be controlling sugarbeet respiration under these conditions.

➤ The glycolytic enzyme, phosphofructokinase, may have a role in controlling respiratory substrate availability, at least in wounded roots stored at 10°C. Changes in its activity, however, were not always associated with changes in respiration rate, suggesting that other unknown factors contribute to respiratory control.

➤ Oxygen is a substrate for respiration and may limit respiration if present at insufficient concentrations. The possible regulation of respiration by limited oxygen availability will be examined in the next 12 months.

References

Klotz, K.L. (2003). Identification of the sucrose metabolizing enzymes responsible for sucrose losses during sugarbeet development and storage. *Sugarbeet Research 2002 Report*, C18-C22.

Klotz, K.L., and Anderson, M.D. (2003). Characterization of respiratory processes in sugarbeet roots during postharvest storage. *Sugarbeet Research 2002 Report*, C23-C27.

Shugaev, A.G., and Bukhov, N.G. (1997). Opposite trends of seasonal changes in ADP content and respiration rate in sugar beet roots. *J. Plant Physiol.* **150**, 53-56.

Theurer, J.C., Wyse, R.E., and Doney, D.L. (1978). Root storage respiration rate in a diallel cross of sugarbeet. *Crop Sci.*, **18**, 109-111.

Wyse, R.E., and Dexter, S.T. (1971). Source of recoverable sugar losses in several sugarbeet varieties during storage. *J. Amer. Soc. Sugar Beet Technol.* **16**, 390-398.

Wyse, R.E., Theurer, J.C., and Doney, D.L. (1978). Genetic variability in post-harvest respiration rates of sugarbeet roots. *Crop Sci.*, **18**, 264-266.

SUGARBEET RESEARCH

2003 REPORT

Section D

Sugarbeet and Bean Research Unit
Agricultural Research Service – USDA
East Lansing, Michigan

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Manuscripts published

Saunders, J.W., Halloin, J.M., McGrath, J.M., (2003) Registration of EL52 and EL48 sugarbeet germplasm releases. Crop Sci. 43: 744-745.

De los Reyes, B.G., McGrath, J.M. (2003) Cultivar-specific seedling vigor and expression of a putative oxalate oxidase germin-like protein in sugar beet (*Beta vulgaris* L.). Theor. Appl. Genet. 107: 54-61.

McGrath, J.M. (2003) Registration of SR96 and SR97 smooth-root sugarbeet germplasm with high sucrose. Crop Sci. 43: 2314-2315.

De los Reyes, B.G., Morsy, M., Gibbons, J., Varma, T.S.N., Antoine, W., McGrath, J.M., R. Halgren, R., and M. Redus, M. (2003) A snapshot of the low temperature stress transcriptome of developing rice seedlings (*Oryza sativa* L.) via ESTs from subtracted cDNA library. Theor. Appl. Genet. 107: 1071-1082.

Trebbi, D., McGrath, J.M. (2003) Sucrose accumulation during early sugar beet development. Proceedings of the Joint Meeting of the International Institute for Beet Research and the American Society of Sugar Beet Technologists. pp. 267-271.

McGrath, J.M. (2003) Alphabet soup for beets: Status of ESTs, BACs, RILs and other genomic sundries. Proceedings of the Joint Meeting of the International Institute for Beet Research and the American Society of Sugar Beet Technologists. pp. 261-266.

De los Reyes, B.G., McGrath, J.M. (2003) Differential expression of glyoxylate enzymes in sugar beet related to seedling vigor. Proceedings of the Joint Meeting of the International Institute for Beet Research and the American Society of Sugar Beet Technologists. pp. 405-408.

De los Reyes, B.G., Myers, S.J., McGrath, J.M. (2003) Differential stress-induction of glyoxylate cycle enzymes as a marker for seedling vigor in sugar beet (*Beta vulgaris*). Mol. Gen. Genomics 269: 692-698.

Abstracts Presented

Trebbi, D., McGrath, J.M. Genetic analysis of sucrose accumulation in sugar beet. Plant and Animal Genome XI, San Diego, CA. January 15, 2003.

McGrath, J.M. Sugar beet seedling vigor. W-168 Seed Biology Group, Lexington, KY. January 17, 2003

Dale, T.M., Renner, K.A., McGrath, J.M. Response of sugarbeet (*Beta vulgaris*) varieties and populations to post-emergence herbicide treatments. 1st International Joint IIRB-ASSBT Congress, San Antonio, TX. February 26 – March 1, 2003.

Introduction

The Sugarbeet and Bean Research Unit at East Lansing, MI has projects involved with sugarbeet, dry bean, apple, and cucumber. Currently, a sugarbeet geneticist and an agricultural engineer working on technologies for high-speed apple sorting are active. Two positions are open, a sugarbeet pathologist and a dry bean geneticist, and these will be recruited in the coming months. The sugarbeet program has three primary areas of investigation. First is breeding enhanced germplasm for adaptation to the Eastern US growing areas, with a priority on high sucrose, smooth root, and seedling disease resistance. Second is determining genetics of agronomic traits including sucrose accumulation, inheritance of seedling disease resistance, developing recombinant inbred lines, and constructing and characterizing molecular tools for the community (genetic maps, expressed sequence tags, bacterial artificial chromosome libraries). Third is investigation of seedling vigor, including field emergence and stand establishment, stand persistence, development of *in vitro* germination and vigor tests, and molecular characterization of early plant development.

Sugar beet activities conducted in cooperation with Saginaw Valley Bean and Beet Farm during 2003

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The agronomic test (03BB01) was planted April 28, 2002 with a four replication, randomized complete block design on land North of Swan Creek Rd. in Saginaw, MI. The previous crop was soybean. The ground was fall chisel plowed followed by frost tillage in the early spring. All tests were treated pre-emergence with 5.6 pt/ac of Pyramin and 3 pt/ac of Nortron after planting. Nitrogen fertilizer was side-dressed at the rate of 120 lbs/ac. Eighty entries were planted, each with a plot size of one row by 27 feet. Hand thinning was completed on June 16, at an average spacing of 6 inches between plants. The test was sprayed four times for Cercospora leaf spot following recommended spray rotations. Plots were harvested on September 30, with the USDA one-row research harvester. Harvest plot length for the test was 24 feet. Plots were shortened to remove alley border row effects.

Seed planted was untreated. Poor germination and emergence, either due to the seedling disease or low seed quality or both, of 107 plots of the total 320 necessitated replanting, which were replanted with a single variety (SR95) on June 10. Replanted plots were not harvested. Untreated seed was used purposely to assist breeding for enhanced stand establishment that would have otherwise been obscured. Selections from this test are being used as mother roots in further breeding efforts.

The purpose of this test was threefold. First was to evaluate results of 'on-the-go' sucrose analyses using Near Infra Red (NIR) instrumentation. The one-row harvester was tested in 2002, and in July of 2003, a NIR instrument was purchased and calibrated before harvest using 19-week old beets, and hence the prediction model was known to have deficiencies. However, results were promising for using NIR as a breeding and selection tool (Table 1). The second goal of this test was to obtain a more representative set of data for the NIR calibration model using the Michigan Sugar Co. tare lab results, and a 15 beet sample from 53 harvested plots (representing 14 entries) was analyzed with NIR (both fresh cut and brei samples) and at the tare lab. Calibration data was also collected at other sites. Third, plots of Cytoplasmic Male Sterile

(CMS), O-type, and their experimental hybrids were planted from archival germplasm held in East Lansing. These materials will form the foundation of breeding efforts geared to release of improved seed parent germplasm (e.g. monogerm, CMS) with smooth-root, high sucrose, and resistance to diseases. Selections were made from 112 plots (49 entries).

The 14 entries used for NIR and polarimetric sucrose evaluations are listed in Table 1. The entries represent the wide range of sucrose contents present in sugarbeet and related germplasm, and include one commercial entry (Hilleshög E17), two genetically broad germplasm lines with smooth-root and high sucrose parents (02B089 and 02B090), one smooth-root composite population twice selected under Rhizoctonia crown and root rot disease pressure (A012868), one seed parent CMS Maintainer source (C869 O-type), one low sucrose germplasm (red beet W357B), two obsolete commercial germplasm lines (USH20, GW359), and six recent East Lansing germplasm releases (SRxx and EL0204). Recoverable White Sugar per Ton (RWST) and Recoverable White Sugar per Acre (RWSA) were calculated using polarimetry results. Table 1 lists entries in order of decreasing RWSA, where the three most recent East Lansing germplasm releases performed well with respect to the commercial entry, and similar with previous years.

Table 1: Harvest data for agronomic test 03BB01 sorted by decreasing RWSA (Recoverable White Sugar per Acre).

Entry	Water (%) Field	Water (%) Brei	NIR field	sucrose (%) NIR brei	Polarimetry	Tons/Ac	RWST	RWSA	CJP %
EL0204 (WC020542)	81.05	81.93	11.83	12.05	16.23	26.6	231.1	6134.8	93.55
SR96 (WC980437)	78.45	79.28	13.55	13.75	18.10	21.7	263.4	5706.9	94.28
SR97 (WC970311)	79.28	79.68	13.18	13.18	17.28	22.2	251.6	5591.9	94.45
SR87 (WC960444)	81.28	81.13	11.58	12.80	15.80	24.4	225.4	5535.6	93.88
Hilleshög E17	79.08	80.55	13.20	12.45	18.25	20.3	267.0	5404.3	94.50
02B089 (SR F3 mm)	80.97	81.80	11.77	12.50	15.90	20.8	229.9	4784.6	94.43
SR94 (WC960448)	80.45	81.15	12.40	12.33	16.67	19.2	248.6	4765.4	95.80
SR95 (WC970308)	80.55	81.35	11.98	12.05	16.73	20.0	239.4	4754.8	93.80
USH20 (WC990379)	80.38	80.25	12.20	13.10	16.53	19.3	240.7	4668.6	94.58
02B090 (SR F3 M-)	80.15	81.20	12.55	12.65	16.30	20.0	233.7	4663.4	93.93
A012868 (SR 2XRhz)	81.13	80.48	11.75	13.35	16.05	20.2	227.6	4594.5	93.48
GW359	79.80	78.40	12.73	14.40	18.00	17.3	260.2	4493.4	93.97
C869 O-type	80.38	80.20	12.13	12.43	16.83	14.8	234.4	3450.4	92.48
Red Beet W357B	84.37	89.40	8.90	4.17	1.40	4.2	10.0	41.2	nd
Grand mean	80.45	81.08	12.18	12.33	16.20	19.96	233.19	4788.9	94.04
LSD (0.05)	1.64	2.23	1.23	1.82	2.27	5.96	62.40	1553.70	1.57
CV (%)	1.20	1.70	6.10	8.90	8.60	18.20	16.70	23.40	1.00

Of greater interest was the NIR results and predictions. In general, the NIR model predicted a sucrose content 4 percentage points less than the polarimetry data. The reasons for this are currently unclear, but may relate to the model having been generated from immature roots, differences between sucrose analysis methods (e.g. polarimetry measures rotation of light and NIR results were calibrated on a direct sucrose content assay), or variable distribution of sucrose

within the root areas measured. The relative ranking of entries was similar with either method (Figure 1). Brei NIR was determined immediately after sawing the roots at the B&B Farm.

NIR results were obtained with a 1 cm diameter contact probe. For fresh samples in the field, tips of the harvested roots were cut transversely to reveal a 1.5 cm diameter internal surface to accept the probe. Preliminary laboratory analyses showed that external readings were not as consistent from reading to reading at different root positions as internal readings, and that readings near the base of the root were more consistent that readings at or near the crown (data not shown). Readings at or near the point of maximum root girth were also consistent, however the root structure would have had to have been destroyed on the harvester for this method to be practical, rendering subsequent polarimetry data from wounded roots more problematic.

Figure 1: Correlation Field NIR (Fresh) with Polarimetry or Brei NIR for sucrose content.
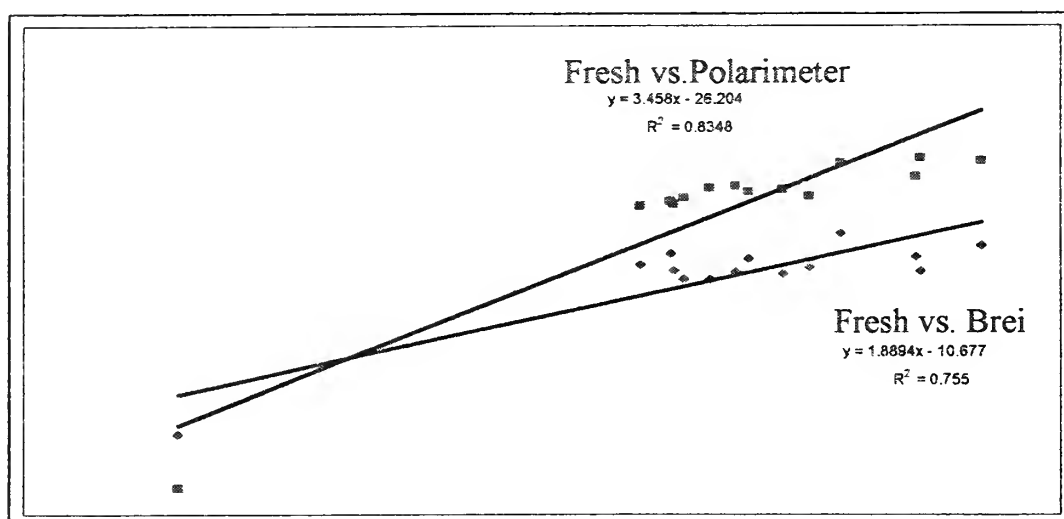
NIR has an advantage in being able to predict water content of roots as well as sucrose content. Water content measurements were less variable than sucrose content values across different readings of the same root, either between fresh and brei measurements (Table 1) or between different root zones (data not shown). Previous results using traditional methods showed that sucrose and water content are inversely related with high correlation coefficients (R^2 = 0.89 to 0.93). Sucrose content plus water content was subtracted from the total root weight to predict the non-sucrose dry matter content (marc). With the exception of red beet, the ratio of sucrose to marc was nearly constant (Table 2). This result implies that further breeding efforts should focus on total yield components rather than increasing the sucrose content *per se*, and validates the use of RWSA as one variety approval criterion component.

The relationship of mean sucrose yield per plot compared to the yield of either water or marc per plot also showed high correlation (Figure 2), however greater variability was seen with water content, suggesting that plot to plot variability may result from different moisture levels within the beets rather than different proportions of sucrose or marc.

A strip trial test (03BB11, planted April 25) consisted of sixteen 500' rows of 02B089 and 02B090, from seed produced at East Lansing in 2001 and 2002. Both populations are similar with the exception that 02B089 is from monogerm selections. Both populations were agronomically similar, as expected, and 48 smooth, nicely shaped, disease free roots were selected from the monogerm population were harvested for inclusion in the seed parent breeding

**Figure 2**: Correlation of sucrose yield with either water yield or marc yield.
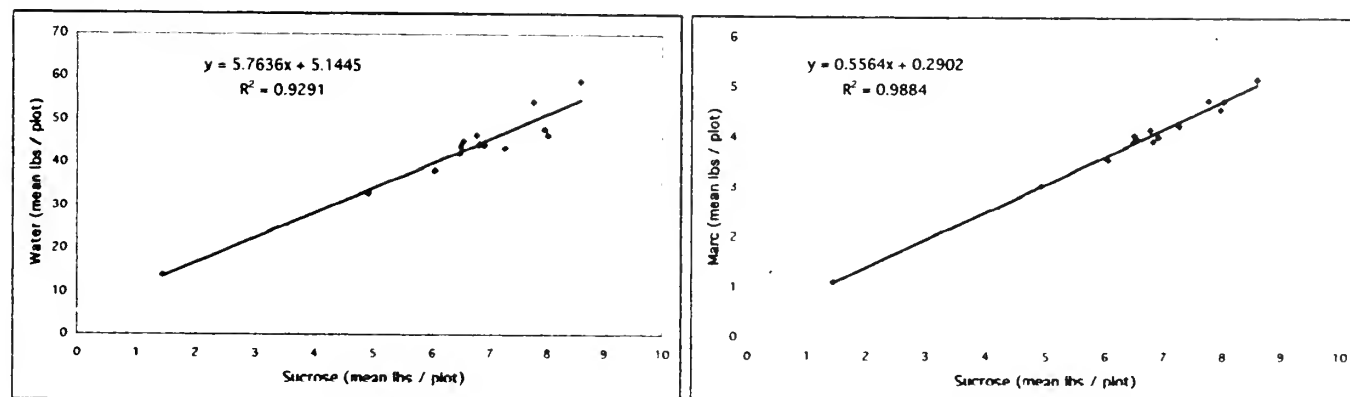
Table 2: Mean yield of sucrose and non-sucrose (marc) dry matter per plot.

Entry	Sucrose (lbs)	Marc (lbs)	Suc / Marc
EL0204 (WC020542)	8.6	5.2	1.7
SR96 (WC980437)	8.0	4.7	1.7
SR97 (WC970311)	7.9	4.6	1.7
SR87 (WC960444)	7.7	4.7	1.6
E17	7.3	4.2	1.7
02B090 (SR F3 M-)	6.9	4.0	1.7
SR94 (WC960448)	6.8	3.9	1.7
02B089 (SR F3 mm)	6.8	4.2	1.6
EL-A012868 (SR 2XRhz)	6.5	4.0	1.6
SR95 (WC970308)	6.5	4.1	1.6
USH20 (WC990379)	6.5	3.9	1.6
GW359	6.0	3.6	1.7
C869 O-type	4.9	3.0	1.6
Red Beet W357B	1.4	1.1	1.3
Grand mean	6.67	4.00	1.65
LSD (0.05)	1.8	1.0	0.1
CV (%)	18.9	18.0	4.6

program. These 48 roots were scanned three weeks after harvest (after cold storage) with NIR to determine relative sucrose contents, which ranged from 10.0 to 17.3 % (Figure 3, note that the average of this line in the agronomic test was 11.8%). These results imply that sucrose content is segregating in this population. To evaluate the utility of this NIR measure as a selection tool, roots were divided into three groups (10-11%, 14%, 16-17%) for separate seed increases and subsequent field evaluation in 2004.

Figure 3: Sucrose content distribution of 48 02B089 roots after 3 weeks of cold storage.
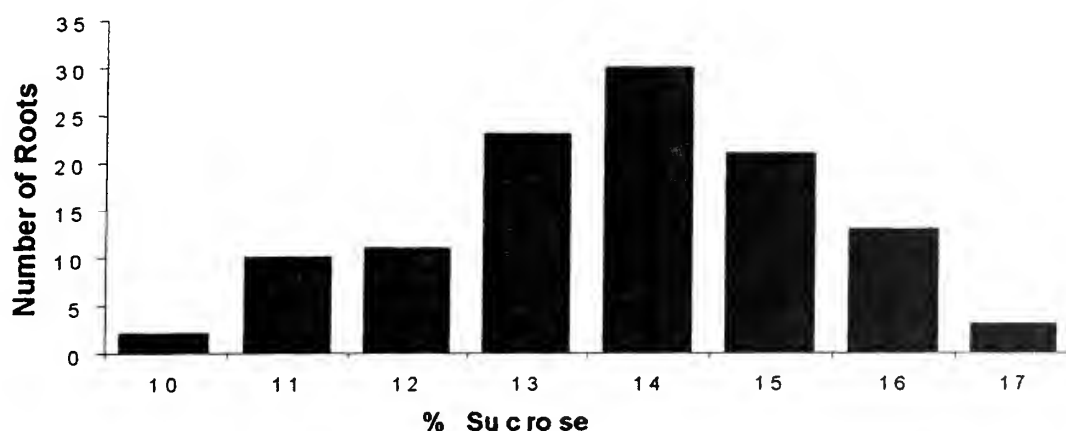
Cercospora leafspot evaluation and selection
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The Cercospora leafspot selection test (03BB14) was planted April 28 with the B&B farm's John Deere vacuum planter. This test received a pre-emergence spray of 5.6 pt/ac of Pyramin and 3 pt/ac of Nortron after planting. Fertilizer was 120 lbs of nitrogen side dressed. Blocking and thinning were done on June 16 to an average spacing of 6 inches.

This test consisted of eight 300' rows with alternate rows of EL50 and L19/SR95. SR95 was replanted over the top of L19 on June 10 due to poor emergence of L19. Both L19 and SR95 are highly susceptible to Cercospora leaf spot caused by *Cercospora beticola*, and were used as spreader rows to select additional resistance from within the highly resistant germplasm of East Lansing release EL50. An inoculation of Cercospora spores was sprayed on all rows on July 1, with generous assistance of Monitor Sugar, Co. Selections were made on September 18. Disease pressure was high in this selection plot. Forty-one EL50 roots showing minimal leaf spot symptoms (< 2 spots per mature leaf) relative to its ca. 2,400 siblings were selected for 2004 seed production at East Lansing. Thirty-one SR95 roots were also selected for improved performance, however their symptoms were more severe (>25 spots per mature leaf).

Real-time PCR analysis of sugar beet BAC library
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A 6.1X Bacterial Artificial Chromosome (BAC) library was constructed using US H20 as the source DNA. The average insert size was >100kb. Results previously reported indicated >99% probability of recovering any clone of interest from this library. In order to facilitate screening the library, a PCR-based resource was developed with assistance of member companies of the BSDF. All 36,864 individual BAC clone DNAs from 100 384-well microtiter plates were isolated and divided into eight groups. All DNA from each group was pooled, resulting in eight Super Pools (SP). Each Super Pool was further subdivided into one of 36 'Matrix' Pools for subsequent localization of a specific PCR amplified fragment to a specific BAC clone. To test efficacy, Super Pools were screened using a PCR/SYBR Green-based assay with 29 gene-targeted primers and 42 Simple Sequence Repeat (SSR) markers (Table 3). Seventeen (58.6%) of the gene-target primers and 35 (83.3%) of the SSR markers were able to be located to specific Super Pools. It should be noted that failure to detect a sequence is more likely due to primer failures than the lack of that gene in the library. Matrix Pools corresponding with putative positive SP hits were screened with three primers (calmodulin, ABC transporter, BvGer171). Single clones were identified with the calmodulin primers in each of SP7 and SP8, and for ABC transporter (SP5, SP8). Multiple signals were observed in SP1 and SP5 when screened with BvGer171, and these were difficult to assign to a specific clone because of their redundancy since 6 to 12 copies of this or similar sequences are present in the beet genome. Thus, the strategy to assign clones from pools to individual clones appears to be valid for single copy genes or members of small gene families, but more problematic for higher copy number sequences. Many PCR products showed multiple peaks (bands) when analyzed on a real-time PCR instrument. Each peak was characterized by a specific melting temperature (Tm). It is yet unclear whether these peaks represent alleles at a locus, or duplicate genes amplified with a single primer set. It is concluded that the pools will be useful, in part, to locate genes to BACs and construct a physical map of sugarbeet.

Table 3: Genes and SSRs located to BAC Super Pools (SP).

Primer Name	Source	PCR product Tm	SP with peaks detected
ABC transporter	BI543560	74,82	1,4,5,8
adenine triphosphatase	BI543544	0	none
adenylhomocysteinase	BI543393	73,85	1
allergen	BI095948	77,81	1,2,3,4,5,7
beta amylase	BF011014	0	none
BvGer165rss	AF310018	72,79	1,5,6
BvGer171	AF310017	70	1
BvGer172	AF310018	0	none
calmodulin	BI096069	78	3,4,6,7,8
carboxyphosphonoenol pyruvate mutase	AW697745	78	1
choline 1-oxogenase	BI543591	71	1,6
cystein protease	BE590278	74,78	2,3
enolase	BI543290	74,77	2,3,4,6
FBP aldolase	BI096185	74,81	1,2,3,4,5,6
glutamine-1-semialdehyde	BI095889	0	none
heat shock protein 81-2	AW897750	75	1,7
hexokinase	BI543276	86	all eight
HSP-2	BI543424	72,81	1,3,4,5,6,7,8
hydroxymethyl transferase	BI095900	77	2,5
isocitrate lyase SNP	BI095941	71,75	1,8,7
ketolacid reductoisomerase1	BI543390	0	none
ketolacid reductoisomerase2	BI543493	0	none
L-ascorbate peroxidase	BI095962	85	all eight
mNAD-dependent malate dehydrogenase	BI073206	75,81	1,6,8
monodehydroascorbate reductase	BI073264	73,85,87	all eight
mtDNA CMS	MIBVMSCS	71,72,73	1,2,3,4,5,6,7
mybrelated transcription activator	BI543353	0	none
NADH dehydrogenase	BI543488	87	all eight
oxoglutarate/malate translocator	BI073250	0	none
SB04	Panella	74	all eight
SB06	Panella	78,81	all eight
SB13	Panella	75,79	all eight
SB15	Panella	83	2,3,5
USDA01	EST	0	none
USDA02	EST	79, 80	1,2,3,4,5
USDA03	EST	73, 80, 81	all eight
USDA04	EST	77,78,83,84,86	1,3,4,5,6,7,8
USDA05	EST	76, 81	all eight
USDA07	EST	77, 80, 83	all eight
USDA08	EST	79, 80, 85	all eight
USDA10	EST	75,78,79,83,84	all eight
USDA13	EST	82, 85	all eight
USDA16	EST	80,84,85,88	all eight
USDA19	EST	75,81,88,88	all eight
USDA20	EST	77, 82, 85	all eight
USDA21	EST	81, 83	all eight
USDA22a	EST	76,77,83,84,87,88	all eight
USDA23	EST	78, 84	all eight
USDA29	EST	73,82,83,84	all eight
USDA30	EST	75, 76	all eight
USDA31	EST	86	all eight
USDA35	EST	74,75,79,80	all eight
MPIZ10	EST	77,82	4,6
MPIZ18	EST	81,73	1,2,4,6,7,8
FDSB1001	Laurent	77,85	all eight
FDSB1002	Laurent	77,83	all eight
FDSB1005	Laurent	77,84	all eight
FDSB1007	Laurent	74,79	1,2,3,5,6,7
FDSB1008	Laurent	77	1,2,3,5,8
FDSB1011	Laurent	73,78	1,5,6,7
FDSB1023	Laurent	76,83	all eight
FDSB1026	Laurent	75,81	all eight
FDSB1027	Laurent	82	3,5,6,7
FDSB1033	Laurent	78	1,3,6,7,8
CAA1	Viard	71,80	all eight
BMB1	Cureton	73,77	all eight
BMB2	Cureton	0	none
BMB3	Cureton	77,81	2,3,8
BMB4	Cureton	76	3,4,5
BMB5	Cureton	69	2
BMB6	Cureton	80	4,6,7,8

Aphanomyces Disease Nursery

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The disease nursery test (03BB13) was planted May 19, 2003 in a three replication, randomized complete block design, north of the Bean & Beet farm pond in Saginaw, MI. The previous crop was soybeans and the ground had been fall chisel plowed followed by spring frost tillage. The seedbed was ideal for planting. Fertilizer was 120 lbs of nitrogen side dressed. Blocking and thinning were done on July 8 to an average spacing of 6 inches. Treatment for Cercospora leaf spot control was applied twice, and Quadris was not used.

Sixty-six entries were tested, representing single plant seed harvests if sufficient seed was available, or combined seedlots from sibling seed harvests if sufficient seed from a single individual was not available. These entries predominantly derive from crosses between C869, a monogerm self-fertile Western US breeding line with no Aphanomyces selection history; SP6822, a multigerm self-sterile Eastern US breeding line with resistance to Aphanomyces and the pollinator parent of USH20; and two Plant Introductions (PI540409 and PI540625) collected in 1990 that showed excellent Aphanomyces resistance in a germplasm screen in Texas. Crosses between and among this germplasm were conducted from 1997 through 2001, and the entire germplasm set was field evaluated here. For crosses derived from C869, a seedlot represented a self-pollinated individual (or a mixture of self-pollinated seed). For crosses with SP6822, pollination was uncontrolled and seed was harvested from single mother plants. Additional germplasm tested included four coded entries used as controls in the Betaseed Shakopee nursery, the multigerm smooth-root germplasm tested in the agronomic trial (see above), a breeding line (94HS25), and the recent East Lansing rhizomania resistant release EL0204.

The purpose of this trial was for selection and germplasm evaluation for reaction to the naturally prevalent root diseases in this nursery, including *Aphanomyces cochlioides*, *Pythium ultimum*, and *Rhizoctonia solani*. This trial was replicated at the Betaseed Inc. Aphanomyces nursery in Shakopee, MN. Stand counts at 10, 20, and 30 days were used to assess seedling disease pressure, and harvest stand was used as a gauge of chronic symptoms. Additionally, root morphology and symptoms were observed at harvest, but not specifically scored.

At harvest, most germplasm with a Plant Introduction in their pedigree showed highly branched roots (sprangles) indicative of wild germplasm. Most lines showed brown surface lesions, sometime deep, indicative of chronic Aphanomyces symptoms, however genetic segregation for Aphanomyces reaction was evident. Selections for further breeding were made from 35 of the 198 total plots, representing 27 entries in the test. Selections were based on lack of extensive visual disease, typical sugarbeet root shape and lesser degree of sprangles, and yield potential based on relative size and weight of roots. One entry (Entry 50, SP6822-4 x 625-4) showed negligible disease symptoms, no sprangles, and a nicely shaped taproot. Forty-one of these showed lesions <1 to 5 mm restricted to the lenticel regions, and may represent a source of near-immunity to Aphanomyces disease.

Stand establishment at 20-days was considered maximal, as is reflected in the sort order of Table 3. Generally, germplasm bred at East Lansing showed good emergence as expected. Interestingly, 20-day stand counts for Entry 50 were significantly higher than all but one other entry (51) and neither of these germplasm lines showed stand declines at 30-days after planting. Reasons for improved 30-day stand counts with 13 could be due to delayed germination.

Table 3: Stand count data for disease nursery test 03BB13.

Type	Entry	ID	10-day	20-day	30-day	Harvest
seedlot mixture 2003-19	(6869-20 X 625-5 Bvm)	18	0.0	1.0	4.7	3.0
8BA4522	Betaseed control	61	0.0	18.0	17.0	11.3
single seedlot - 35	(SP6822-4 X 625-4)	35	0.0	28.3	25.3	15.0
single seedlot - 54	(SP6822-4 X 625-4)	54	0.0	29.3	21.0	17.0
seedlot mixture 2003-14	6869 x 409 Bvm	13	0.3	36.7	29.7	13.7
C869	Aphanomyces susceptible	60	0.0	38.0	35.7	17.7
seedlot mixture 2003-12	6869 x 625 Bvm	11	0.0	38.7	31.0	13.7
single seedlot - 49	(SP6822-4 X 625-4)	49	0.0	42.3	36.3	21.7
single seedlot - 36	(SP6822-4 X 625-4)	36	0.0	44.7	36.7	19.3
seedlot mixture 2003-11	6869 x 625 Bvm	10	0.0	45.7	40.0	21.3
seedlot mixture 2003-21	(6869-20 X 625-5 Bvm)	21	0.0	46.0	49.7	20.7
seedlot mixture 2003-13	6869 x 625 Bvm	12	0.0	46.7	49.7	21.7
single seedlot - 48	(SP6822-4 X 625-4)	48	0.0	48.0	38.0	26.0
seedlot mixture 2003-16	(SP6822-4 X 625-4) x (6869-20 x 625-5)	15	0.0	48.3	45.0	24.7
3AC555	Betaseed control	63	1.7	49.3	51.7	22.7
single seedlot - 40	(SP6822-4 X 625-4)	40	0.0	51.3	52.3	23.0
single seedlot - 33	(SP6822-4 X 625-4)	33	0.0	52.0	43.7	21.3
single seedlot - 41	(SP6822-4 X 625-4)	41	2.0	52.7	55.0	24.0
single seedlot - 43	(SP6822-4 X 625-4)	43	0.3	55.7	61.0	29.3
3VS2084	Betaseed control	62	0.3	55.7	58.3	30.3
seedlot mixture 2003-20	(6869-20 X 625-5 Bvm)yiR	20	0.0	56.0	52.3	32.3
single seedlot - 53	(6869-20 X 625-5 Bvm)	53	0.0	56.7	43.0	22.3
seedlot mixture 2003-04	6869-24 X 409-1	3	0.0	57.0	53.0	21.0
seedlot mixture 2003-17	(SP6822-4 X 625-4)	16	0.0	57.0	48.3	26.0
seedlot mixture 2003-02	(SP6822 X 625-4) x SP6822	19	0.0	57.3	68.0	29.0
seedlot mixture 2003-06	6869-14 X 409-5	5	0.7	57.7	46.7	17.0
single seedlot - 38	(SP6822-4 X 625-4)	38	0.0	58.3	54.7	25.0
seedlot mixture 2003-25	6869-27 X SP6822-7	25	0.0	59.3	51.0	23.7
single seedlot - 57	6869 x 409 Bvm / 625 Bvm	57	0.3	59.3	35.7	15.3
seedlot mixture 2003-23	6869-20 X 625-5	23	0.3	63.7	47.0	21.7
seedlot mixture 2003-09	6869-10 X 625-2	8	0.0	64.0	58.0	25.0
single seedlot - 31	(SP6822-4 X 625-4)	31	0.0	64.7	59.3	34.0
single seedlot - 55	6869 x bvmt	55	0.0	65.3	61.0	18.3
single seedlot - 37	(SP6822-4 X 625-4)	37	0.0	66.7	63.0	36.0
seedlot mixture 2003-26	6869 x 409 Bvm	26	0.0	67.7	48.3	21.7
single seedlot - 27	98B001-26 (6869-27 X SP6822-7) Pyth sel Yi	27	0.0	68.0	52.0	26.3
seedlot mixture 2003-07	6869-13 X 625-10	6	0.7	69.0	40.0	23.0
single seedlot - 52	6869-13 X 625-10	52	0.0	69.7	41.7	19.7
single seedlot - 28	(SP6822-4 X 625-4)	28	0.0	72.0	53.3	25.0
02B091	F3-Smooth Root Composite	66	5.0	72.3	83.0	28.7
seedlot mixture 2003-08	6869-13 X 409-3	7	0.0	73.7	66.3	29.0
seedlot mixture 2003-10	6869-1 X 409-7	9	0.0	74.0	53.0	19.7
single seedlot - 42	(SP6822-4 X 625-4)	42	0.0	75.0	70.0	26.0
seedlot mixture 2003-22	(6869-20 X 625-5 Bvm) x 6869	22	0.7	76.0	68.0	30.3
single seedlot - 47	(SP6822-4 X 625-4)	47	0.0	77.3	63.7	31.7
016AB	Betaseed control	64	0.0	78.3	77.7	19.0
single seedlot - 58	6869 x 409 Bvm / 625 Bvm	58	8.0	78.7	73.3	16.0
SP6822	Aphanomyces resistant	59	0.0	82.0	85.7	34.0
seedlot mixture 2003-05	6869-17 X 409-4	4	0.0	82.3	81.7	33.0
seedlot mixture 2003-15	(SP6822-4 X 625-4) x (6869-27 x SP6822-7)	14	0.3	82.3	77.0	29.7
single seedlot - 39	(SP6822-4 X 625-4)	39	1.0	85.0	84.3	29.0
seedlot mixture 2003-24	6869-27 X SP6822-7	24	0.0	89.3	81.0	29.0
single seedlot - 30	(SP6822-4 X 625-4)	30	0.3	89.3	76.3	30.3
single seedlot - 46	(SP6822-4 X 625-4)	46	0.7	90.7	80.0	27.7
seedlot mixture 2003-03	98B001-26 (6869-27 X SP6822-7) Pyth sel Yi	2	0.0	91.0	81.0	32.7
seedlot mixture 2003-01	(SP6822 X 625-4) ms OP	1	0.0	91.3	100.7	34.7
single seedlot - 34	(SP6822-4 X 625-4)	34	0.0	92.3	69.3	30.3
single seedlot - 56	6822	56	0.7	92.7	81.7	29.3
single seedlot - 45	(SP6822-4 X 625-4)	45	0.0	94.7	88.3	31.3
single seedlot - 32	99EL0204	32	3.7	97.7	95.7	45.0
seedlot mixture 2003-18	(SP6822-4 X 625-4)	17	0.0	110.0	118.7	34.7
02B090	F3-Smooth Root Composite	65	4.0	111.3	111.3	39.3
single seedlot - 29	(SP6822-4 X 625-4)	29	1.3	122.0	122.0	35.3
single seedlot - 44	94HS25	44	5.0	123.7	123.7	38.3
single seedlot - 51	(SP6822-4 X 625-4)	51	1.7	151.3	151.3	39.3
single seedlot - 50	(SP6822-4 X 625-4)	50	4.0	161.7	161.7	32.3
Grand Mean			0.65	69.15	63.40	25.69
LSD (0.05)			3.3	30.4	33.6	10.2
CV (%)			315.0	27.2	32.8	24.5

Evaluation Of Stored Sugarbeet Roots

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Post-harvest physiology is a concern for fresh processed foods such as sugar beet. Increasing attention is being focused on the question of genetic differences in post-harvest storage. Roots harvested in East Lansing and at the Bean and Beet Farm in 2002, but not used for breeding purposes, were available for testing long-term controlled storage on sucrose and water contents. Comparison with freshly harvested beets in 2003 from five germplasm lines was possible (from Table 1), but information here is only presented here as a preliminary comparison.

Shortly after harvest in 2002, beets were packed in a 22" x 39" 10-mil clear polyethylene bags that were randomly slit (5 – 10 cm) in 5 to 10 places for ventilation and for escape of ethylene gas, a known ripening promoting hormone. Beets were packed with two large (2 lb size) coffee can volumes of dry wood shavings and the shavings were dispersed among the beets. The bags were stored on wire rack shelving at 4 °C cooler with high humidity and 14 hours of artificial light per day. Approximately one year later on October 7th, 2003, beets were removed from storage and tested for sucrose content by means of NIR testing equipment. A preliminary sucrose and water percentage-capturing model was used for this purpose. A wedge was cut from each beet, using a special rasp saw blade, through the radius of each beet lengthwise. The brei was collected and analyzed. Ten beets were randomly selected as a sample for each stored germplasm line, and values were averaged.

Since beets compared were grown in different years, comparisons are only suggestive. One observation is that sucrose content declined under these conditions from 1.3 to 3.2 percentage points depending of germplasm, and water content increased by –0.8 to 1.9 percentage points over the storage period. These values are likely to be within the range of experimental uncertainty within any one year, thus it will be necessary to measure beets harvested in the same year before and after storage. However, it appears that NIR analyses may be able to quantitatively ascertain loss of sugar under various applied post-harvest storage conditions.

Table 4: Sucrose and water content estimates obtained by NIR on beets stored for one year, and contrasted with fresh sucrose and water content values of the following years harvest where possible.

Entry	Sucrose (%) Stored	Sucrose (%) Fresh	Water (%) Stored	Water (%) Fresh
SR96	11.2	13.8	80.1	79.3
657 cms	11.2		79.2	
SR94	11.1	12.3	80.3	81.2
HS25	10.9		80.6	
SR97	10.2	13.2	80.3	79.7
USH20	9.9	13.1	82.1	80.3
EL48	9.9		81.7	
EL0204	9.2	12.1	82.2	81.9
576cms	8.5		81.7	
LSD (0.05)	2.3	1.6	2.5	1.2
CV (%)	19.0	1.2	2.6	6.1

Rhizoctonia seedling damping off in sugar beets (Project 742)

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Diseases caused by *Rhizoctonia solani* (L) in sugar beets include post-emergence damping off of seedlings, and crown and root rot of mature plants. Sugar beet varieties show varying degree of susceptibility to *R. solani*. Based on vegetative compatibility reactions *R. solani* are sub-grouped into different Anastomosis Groups (AG). *R. solani* AG2 and AG4 are sugar beet pathogens. There are different strains of *R. solani* AG2-2 and AG4 with varying degrees of pathogenesis. *R. solani* is a facultative saprophyte capable of infecting another living organism under some conditions, and can survive for many years by producing small (1 to 3-mm diameter), irregular-shaped, brown to black structures (sclerotia) in soil and on plant tissue which makes it difficult to control Rhizoctonia disease through cultural practices such as crop rotations. The fungus typically causes post-emergence damping-off by attacking the hypocotyls below ground, and severely diseased seedlings collapse and die. The differential ability of isolates to produce sclerotia as survival structure and soil-borne inoculum as well as its saprophytic growth are major importance in the subsequent development of disease. Virulence and pathogenesis describe complex interrelationships between the infecting organism and the host, and the present studies were undertaken to define some of the relationships between the sugarbeet and Rhizoctonia during the infection process in order to begin to deduce opportunities for genetic intervention in the control of the seedling disease. There is no known resistance to seedling Rhizoctonia disease.

A number of objectives relate to this project. One was to develop a reliable method to screen for Rhizoctonia seedling damping –off disease, to screen different sugar beet germplasm for resistance to Rhizoctonia seedling damping –off, and to classify different strains of *R. solani* based on their disease causing ability as virulent (disease), hypo-virulent (infection but no disease), or avirulent (no infection or disease). Others in progress include: compare saprophytic growth and pathogenicity of different isolates of *R. solani*; examine pathogenicity (infection structure formation, penetration, and tissue colonization) during compatible and incompatible plant-pathogen interactions; test relationships between Rhizoctonia seedling damping-off and Rhizoctonia crown and root rot disease for mode of resistance to both diseases; and elucidate the host-pathogen interaction at molecular level.

The disease progress curves established for Rhizoctonia seedling damping off in sugar beet seedlings inoculated at the 2 –4 leaf stage in growth chambers showed three phases of disease reaction on USH20 germplasm. The initial infection (from zero to 9 days post-inoculation) was characterized by rapid appearance of symptoms, the second phase (from 8 to 13 days of post-inoculation) was characterized by little disease progression, and the final phase (14 to 18 days post-inoculation) finalized the outcome of the interaction, either death (compatible interaction) or recovery (incompatible interaction). Virulent AG2-2 (strain R-1) caused seedling damping-off and death of the plant. Seedlings infected with three other isolates (AG2-2 strain W-2, and AG4 strains R6 and R7) showed fewer damping-off symptoms and less mortality than with AG2-2. At post inoculation day (PID) 6, disease severity actually decreased for a period of 1 to 2 days before rising and reaching a plateau by PID 9, but only for AG4 and the avirulent isolate of AG2-2 (i.e. isolate W2). For virulent isolate AG2-2 R1, this same time frame was characterized by a rapid increase in disease severity, followed by a plateau. By PID 14, all plants infected with

the virulent isolate were dead, while avirulent AG2-2 (i.e. isolate W2) and each of the AG4 isolates had begun to recover and were showing limited symptoms. AG2-2 was more damaging to sugar beet seedlings in general. Neither the *in vitro* saprophytic growth rate nor in vitro sclerotium producing ability showed any correlation with the fungal pathogenesis on sugar beet seedlings (data not shown). Data were subjected to analysis of variance (ANOVA) followed by regression analysis of each fungal treatment category using the CATMODE procedure of SAS. Statistical support (95% CI) was obtained showing that, after 13 days, plants treated with AG2-2 virulent (R1) strain was different from all other treatments and control, and thus *R. solani* AG2-2 virulent (R1) strain has caused disease where as plants with the other three strains recovered.

Rhizoctonia seedling damping-off disease progress patterns in the greenhouse were also analyzed using sugar beet hybrid USH20 (Figure 4). Seeds were soaked in 0.3% hydrogen peroxide for 24 hours and allowed to germinate on water soaked Whatman filter paper for 48 hours. Wooden boxes (400cm x 580 cm) were filled to 2 cm below the top with "Baccto" high porosity soil and were arranged in a randomized complete block design. Thirty germinated seeds were planted per wooden box and grown in a green house (25°C, 16 hr light and 8 hr dark photoperiod), watered daily, and fertilized weekly. Seedlings at the 4-6 leaf stage were inoculated with a single isolate of AG 2-2 R1 (virulent) or W2-2 (hypo-virulent). Each seedling was inoculated by adding 0.1 g of inocula (about 20 fungus-infested millet seeds) on opposite sides of each plant, 4 cm away from each seedling. Control plants were inoculated with uninfected, sterile millet. This bioassay for virulence was scored, at daily intervals, on a phenotypic scale as follows:

0: Healthy plant
1: Slight penetration scar visible to naked eye
2: Deep penetration scar very visible; margin of the wound brown to black color
3: Plant showing damping off symptoms, hypocotyl (stem) with water soaked lesions;
4: Plant damping off, leaves wilting
5: Plant dead

Figure 4: Disease curve of greenhouse grown USH20 with different Rhizoctonia isolates.
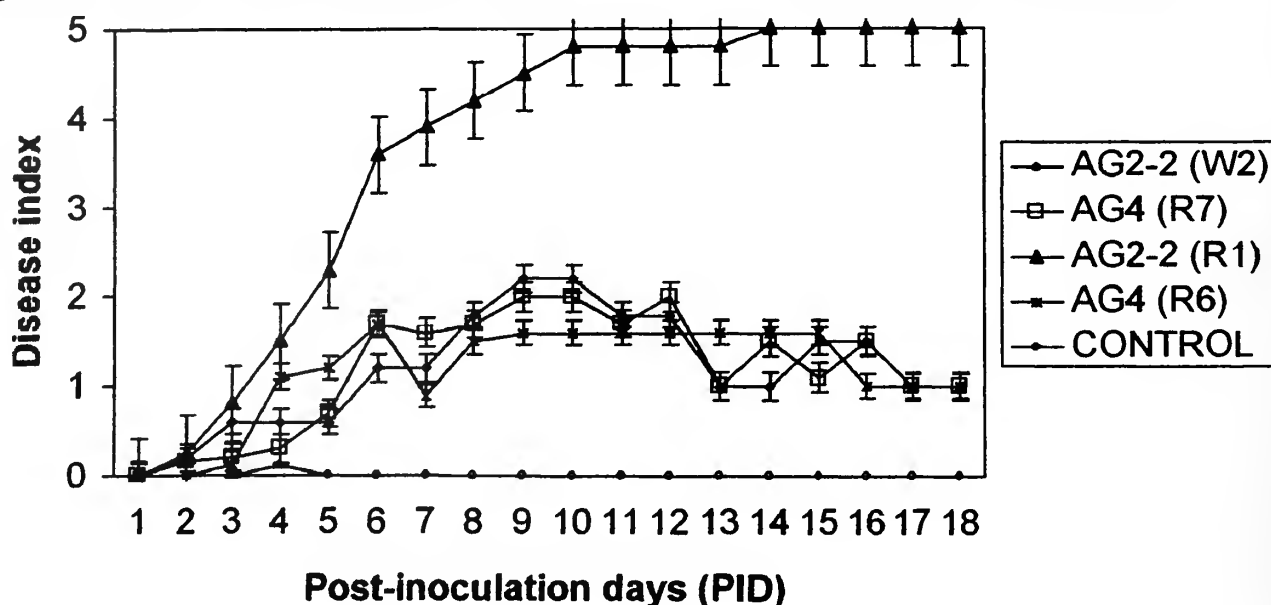
Forty seedlings per treatment (fungal strain) were scored and the average score is reported as disease index (DI) (Figure 4). Ten seedlings per treatment- box were used to make microscopic observations and isolate pathogen as the disease progresses. Each treatment was duplicated.

In the greenhouse, we analyzed different accessions of sugar beet for resistance to Rhizoctonia seedling damping-off disease. Plant material consisted of different releases of sugar beet (*Beta vulgaris* L) that were stored in the seed barn in USDA-ARS, East Lansing, Michigan. The accessions have different levels of resistant to various diseases and other beet quality (e.g. Smooth root) and some were wild varieties. The sugar beet variety EL51 and PI 558513 showed partial resistance to seedling damping off caused by AG2-2 (R1). The sugar beet accessions that were reported to be resistant to Rhizoctonia crown and root rot were susceptible to Rhizoctonia seedling damping off disease suggesting that there is no correlation between these two diseases.

To determine if sugar beet seedlings infected with *R. solani* recovered from damping off symptoms harbored the fungus, thus acting as a reservoir for subsequent Rhizoctonia crown and root rot, we re-isolated fungus from hypocotyls at different stages of disease progress. Whole seedlings were washed in running water for 2 hours and 2/3's of the hypocotyls along with leaves were sliced from the narrow tail of the root. The remaining part of the seedling- about 2 cm of the hypocotyls including the upper porting of the root tissue were washed in sterile water thrice and blot dried. Using a sterile razor blade, slices of asymptomatic tissue were transferred to water agar containing 0.00005% lactic acid, and incubated in the dark at 28 °C. After 24 to 72 hours incubation, tissue pieces were examined under light microscope (4X magnification), and if any fungal hyphae were emerging from these tissues, they were mounted on slides and stained with cotton blue re-observed at 4X and higher power. Soil samples were also collected from the greenhouse-disease-screening-wooden boxes and tested for the presence of *R. solani*.

Rhizoctonia solani can be identified by its distinctive mycelia morphology. We were able re-isolate *R. solani* for up to 12 days post-inoculation from seedlings that were inoculated with *R. solani* AG2-2 (R1) virulent strain. From the seedlings that were inoculated with *R. solani* AG2-2 (W2) hypo-virulent strain we were able to re-isolate *R. solani* only up to 9 days after inoculation. Other sugar beet seedling pathogens were not recovered. These data suggest that seedlings 'cured' of Rhizoctonia seedling damping off are disease free and the fungus is absent, thus is unlikely to supply inocula for subsequent disease chronic crown and root rot.

Observations indicate that *R. solani* hypo-virulent strains initiate infection but fail to establish and cause disease. We wondered if induced resistance to subsequent infection by virulent strains could be accomplished with hypo-virulent pre-inoculation. Sugar beet seedlings were grown in the greenhouse. Two-week old seedlings were inoculated with W2 (hypo-virulent). After 10 days, test seedlings were again inoculated with R1 (virulent). Each treatment was duplicated. Results indicate prior infection by hypo-virulent strain does not induce host resistance.

Rhizoctonia seedling damping-off disease progress pattern in the field was analyzed in the field, with plots arranged to separate treatments with different strains of *R. solani* at the Botany Farm in East Lansing, Michigan. Seven replicates, each 20' long containing from 30-50 plants of four germplasm lines (USH20, 00B041– a Hogaboam-era accession, 01B024-a Rhizoctonia Smooth Root selection, and EL51). Treatments were AG2-2 isolates used in growth chamber and greenhouse screen; namely *R. solani* AG2-2 R1 (virulent strain), AG2-2 W2 (hypo-virulent), as well as the traditional East Lansing AG2-2 Michigan isolate 7201 as a positive control. The

fourth treatment was a negative control inoculated with sterile millet seeds. After 2 weeks of planting, the field was thinned manually to 4" between seedlings. At the 6-8 leaf stage (about 2 weeks after emergence) each seedling was inoculated by adding about 3.3 g of inocula on one side of each plant, 4 cm away from each seedling. The incidence and development of *R. solani*-induced sugar beet seedling damping-off was assessed by counting the number of emerged seedlings (stand count) in each plot at 21 and 35 days after inoculation. Symptoms of *R. solani*-induced damping-off were observed on all sampled seedlings (i.e. 10 % of wilted seedlings were harvested and examined). Tissues from infected roots and/or crowns of all sampled seedlings yielded *R. solani* when plated on Potato Dextrose Agar. Other sugar beet seedling pathogens, including Aphanomyces were not recovered. The stand was generally lower in plots that were inoculated with *R. solani* than in those that were inoculated with sterile millet. The number of dead plants was low in sterile millet treatments and in treatment plots inoculated with hypo-virulent strain W2, compared to that of 7201 and R1 virulent strains.

Seedling results from field inoculation after 21 days (3 weeks) are presented in Figure 5. No seedlings died that were inoculated with sterile millet (negative control). Virulent isolate R1 caused the greatest mortality, however little mortality was seen with EL51. Virulent isolate 7201, the traditional source of East Lansing field inocula, showed intermediate levels of mortality, and caused little mortality in the twice selected for Rhizoctonia reaction Smooth Root germplasm 01B024. Hypo-virulent isolate W2 also showed minimal mortality.

Plant stand at 5 weeks post inoculation showed the same trend (Figure 6), suggesting disease did not progress rapidly in this early part of the season. Final stand counts were more dramatic, with only EL51 showing a high final stand count (data not shown), however these were super-inoculated mid-season with 7201 (virulent).

Figure 5: Rhizoctonia seedling damping off in the field at 21 days post-inoculation, as compared to control. (-) ve control is sterile millet inoculated seedlings, (+) ve control is 7201 virulent inoculated.
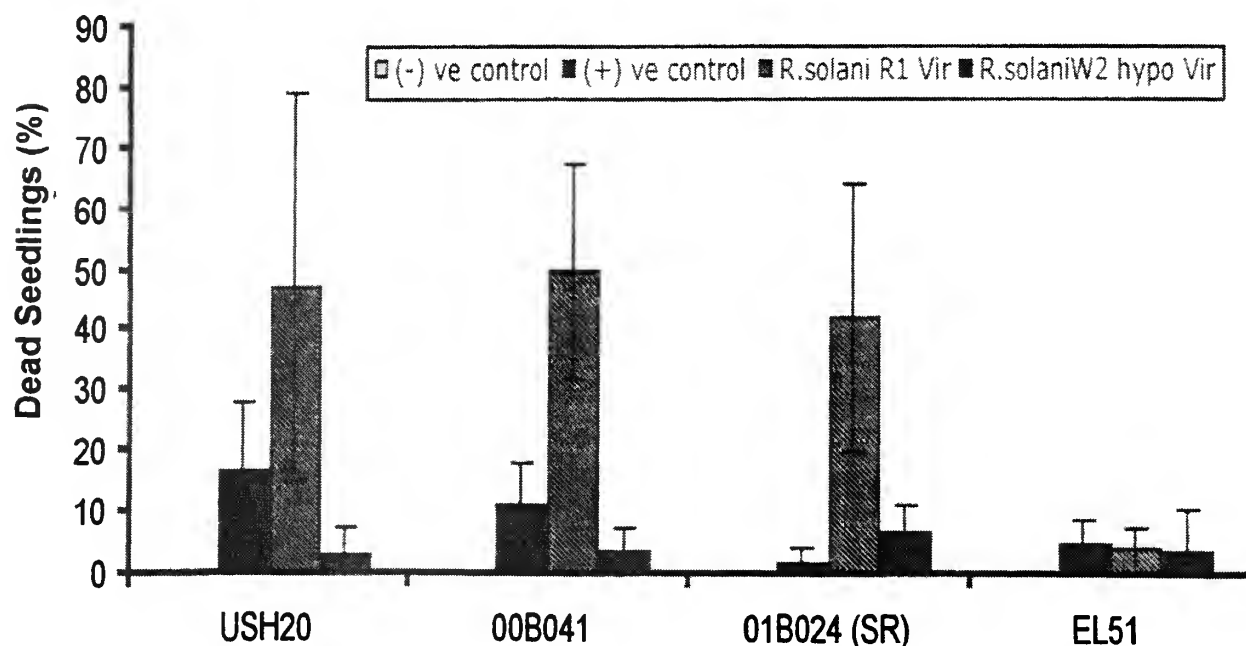
Figure 6: Field survival of inoculated seedlings at 5 week post-inoculation. Plots inoculated with 7201 are not shown (results available from the authors).
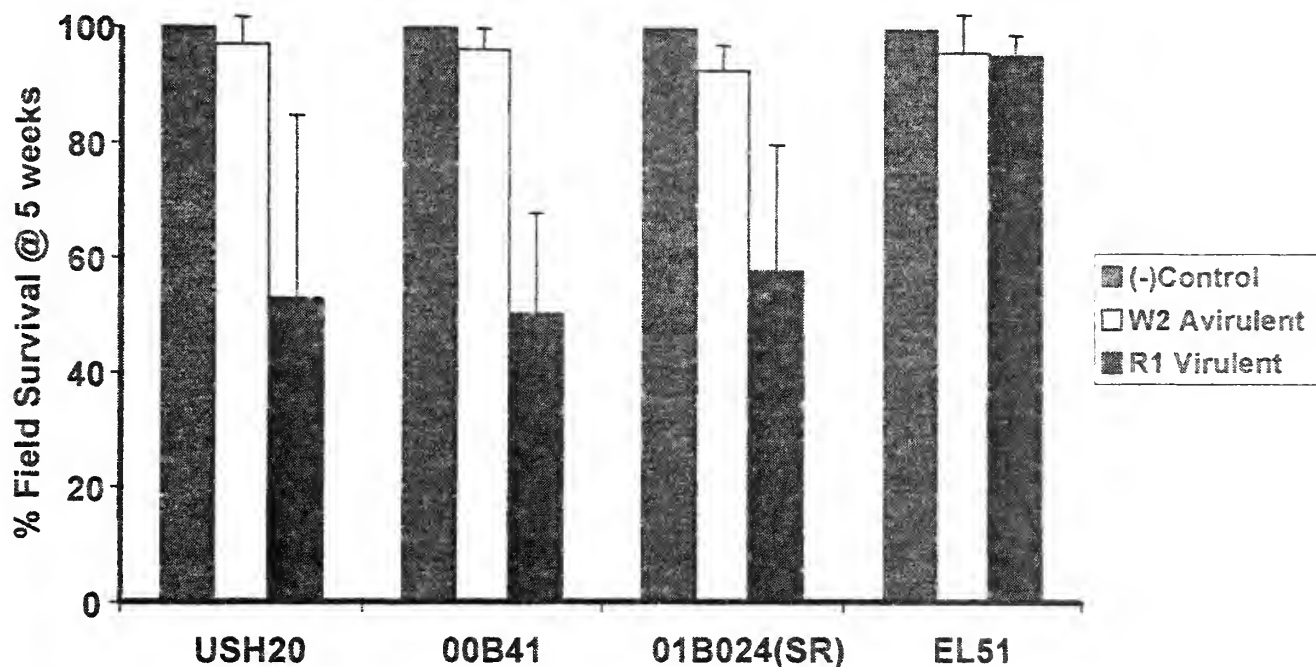
Sugar Beet Seed Germplasm Testing of Resistance to Sugar Beet Cyst Nematode
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The cyst nematode *Heterodera schachtii* is responsible for approximately 90% of all nematode related sugar beet damage (1). Fields affected by sugar beet cyst nematode (SBCN) often appear wilted and underdeveloped. Leaves of affected plants may remain green but can develop and distinct yellowing (1). Roots have excessive fibrous root formation and the storage roots can often appear sprangled or have severe branching (1). When the infective juvenile enters into the tap root it destroys the zone of elongation which causes excessive branching which accounts for the occasional two part beet. "Control strategies typically include crop rotation and pre-plant nematicides, although some granular nematicides may be applied post-plant" (2). With these methods being potentially and economically harmful, focus remains on developing resistant germplasm lines.

This experiment was an initial test into the development of an SBCN assay in the greenhouse whereby selections for further breeding could be performed. A small number (perhaps as few as 16) of breeding lines appear to be resistant to SBCN, but no commercial cultivars are marketed at this time, although the positive control used here (a breeding line from Syngenta, Hil-2) may be the most advanced germplasm available. Resistance in Hil-2, as well as N224 (Lewellen), is derived from *Beta procumbens*. Other potential resistance sources are from Beta vulgaris ssp. Maritima, and include an isolation from KWS (N172), WB242, and a potentially novel source from the Salinas breeding program. Ultimately, confirmation and characterization of the new

Salinas SBCN resistance is the goal of this project, and presented here are the methods and results from the initial screening procedure using the above named breeding lines as well as the susceptible commercial hybrid Hilleshög E17.

Materials and Methods

H. schachtii extraction and development. Cysts were collected from soil from Michigan's Saginaw Valley. Soil (100 ml) was placed in a bucket of water and washed. The water/soil solution was filtered through a 16 over 80 mesh screens, and the filtrate was rinsed using a heavy sucrose solution (615 g / l) into 100ml centrifuge tubes containing 50ml of a heavy sucrose solution. The tubes were spun at 2000 rpm for 2 min, the solution was decanted and filtered through 20 over 400 mesh sieves, and finally filtered into 15x85ml test tubes to be crushed. The cysts were then crushed over a 60 mesh sieve and rinsed into another 15x85 ml test tube. The remaining solution contained nematodes at the J2 stage and eggs only. The concentration was adjusted to 1000 J2s and eggs/ml for inoculation.

Plant development. Seeds of four germplasm lines tested were planted in moist (fine) grain vermiculite. The plant containers were placed upon temperature tanks set at (24°C) under a (16 hour) light period for two weeks. The plants were watered once a day and fertilized with Peters 20-20-20 fertilizer solution (25 grams/gallon).

Plant Inoculation. At the end of two weeks, 'Conetainers' (150cc; 23 x 4.1 cm; Figure 1) were filled half way with steam-pasteurized sandy soil (90% sand). A hole was formed in the soil and a single plant was placed in the hole. Two-thousand J2s and eggs were placed directly onto each plant's roots using a syringe. Soil was then placed on top of the roots and each plant was watered. Seven plants were planted for each variety. The plants were grown in the greenhouse under 16 hr photoperiod at a temperature of 24 °C day and 21 °C night.

Nematode Extraction. At the end of both six and eight weeks the plants were taken out of the green house and the nematodes were extracted. A bucket was filled with water and a Conetainer was hit on the side of the bucket to remove the entire plant. The roots were gently rubbed between the hands. The plants were saved and the roots were weighed. Nematodes were isolated as described above.

Results and Discussion

Clear differences were observed between individuals and germplasm lines in response to SBCN infection (Table 5), particularly by eight weeks after infection under the conditions used here. One variety, Hil-2, was shown to have uniform resistance to sugar beet cyst nematode as expected. Apparent segregation was evident for N224 and N172, also as expected. Susceptible line E17 was variable, but counts of cyst and white females were higher than with other germplasm.

By week six, it was evident but not statistically significant, as to which germplasm was going to be more or less susceptible, suggesting that this is not long enough for the nematode to develop. Differences were clearer on average at week eight, however another time interval would have to be done to determine if the white females seen would in fact develop into cyst and if those cysts would be viable or not. The cysts that were seen on Hil-2 were small and, when crushed, not many eggs or J2s were seen, leading to believe that the plant variety may have slowed the nematode's development.

More time intervals may be needed to get a clearer picture of resistance of the varieties. It

was shown here that six weeks may not long enough to develop significant discrimination. The plant's response to the nematode could be monitored using the method described here to find when the resistance takes place and how it affects the plant and the nematode. This may also be done by growing plants in sterile media in test tubes and then inoculating the plant with J2s and eggs. Growing the plant in a clearer medium may viewing the roots and infection process directly.

Figure 7: Conetainers and plants after inoculation in the greenhouse.

Literature Cited

1. Steele. A.E. 1984. "Nematode Parasites of Sugar Beet" pp. 507-569 in: Plant and Insect Nematodes. W.R. Nickle, ed. Marcel Dekker, New York.

2. Caswell E.P., MacGuidwin A. E., Milne K., Nelsen C.E., Thomason I.J., Bird G.W. 1986. "A Simulation Model of Heterodera schachtii Infecting Beta vulgaris." Journal of Nematology 18(4):512-519.

Table 5: Counts and measures of central tendency and dispersion for SBCN inoculations taken at eight weeks after inoculation.

Trial Number	ID	White Female	Cyst	Total
7-A	Hil-2	0	0	0
7-B	Hil-2	0	0	0
7-C	Hil-2	0	6	6
7-D	Hil-2	0	3	3
7-E	Hil-2	na	na	na
7-F	Hil-2	0	3	3
7-G	Hil-2	0	7	7
Total		0	19	19
Mean		0	3.17	3.17
Std. Dev.		0	2.93	2.93
8-A	N224	0	8	8
8-B	N224	169	47	216
8-C	N224	0	4	4
8-D	N224	2	5	7
8-E	N224	116	59	175
8-F	N224	0	0	0
8-G	N224	5	9	14
Total		292	132	424
Mean		41.71	18.86	60.57
Std. Dev.		70.55	23.76	93.03
9-A	N172	0	13	2
9-B	N172	0	2	13
9-C	N172	5	17	22
9-D	N172	2	28	30
9-E	N172	10	64	74
9-F	N172	115	43	158
9-G	N172	14	15	29
Total		146	182	328
Mean		20.86	26.00	46.86
Std. Dev.		41.84	21.15	53.96
1-A	E17	108	25	133
1-B	E17	308	82	390
1-C	E17	92	67	159
1-D	E17	82	70	152
1-E	E17	25	15	40
1-F	E17	70	25	95
1-G	E17	85	40	125
Total		770	324	1094
Mean		110.00	46.29	156.29
Std. Dev.		91.07	26.43	110.64
overall p (0.95)		0.021	0.03	

SUGARBEET RESEARCH

2003 REPORT

Section E

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Ann C. Smigocki

Introduction

The sugarbeet root maggot (SBRM), *Tetanops myopaeformis* Roder, is considered a major pest of sugarbeet in the United States and Canada where greater than half or all of the sugarbeet acreage, repectively, is infested. Yield losses range from 10 to 100% as developing larvae feed on tap and feeder roots throughout the growing season causing damage either by severing the taproots of seedlings or badly scarring the surface of larger roots. Granular insecticides of the carbamate or organophosphate classes are often used to reduce larval populations but control is inconsistent. In addition, many of these pesticides are being re-evaluated as mandated by the Food Quality Protection Act of 1996 and may be removed from the list of approved insecticides, leaving few alternatives. No effective biological control measures are currently on the market. A biocontrol fungus, *Syngliocladium tetanopsis*, has been patented as a naturally occurring pathogen of SBRM and is currently in the process of evaluation and development (Hodge et al., 1998; Wozniak, 1999, Wozniak and Smigocki, in preparation). Similarly, two entomopathogenic fungi, *Beauveria bassiana* and *Metarhizium anisopliae*, have shown promise in preliminary screenings and field trials (Campbell et al., 2000b). The lack of effective control measures that do not rely on broad-spectrum insecticides has hastened the search for environmentally friendly alternative strategies.

Molecular approaches to enhance disease and insect resistance in sugarbeet have been hampered by a general lack of a reliable gene transfer method, a small pool of well characterized defense genes, and knowledge of sugarbeet defense responses. Our efforts are focused on several approaches geared towards the development of effective strategies for the control of SBRM (Table 1). One of the approaches involves the manipulation of the production of toxic compounds *in planta*. These compounds are mainly products of secondary metabolic pathways, many of which have been shown to play a role in plant defense responses. Our efforts are also aimed at characterizing sugarbeet defense response mechanisms. Profiling of genes in resistant sugarbeet lines is an approach that will provide useful information for developing new control strategies for the root maggot and other pests. Another approach involves the development of genetically modified sugarbeets that express proteinase inhibitor (PI) genes to specifically target midgut proteases of SBRM larvae. By blocking the major classes of digestive proteases in actively feeding maggots, the assimilation of nutrients from ingested foods would be inhibited and thus thwart the normal growth and development of the insect (Wilhite et al., 2000).

Table 1. Molecular approaches for control of the sugarbeet root maggot.

- **Development of sugarbeet gene transfer methods**
- **Cytokinin-induced insecticidal compounds**
    - **Modulation of secondary metabolism**
    - **Cytochrome P450 genes**
- **Identification of insect/disease resistance genes in SBRM resistant lines**
    - **sugarbeet defense response mechanisms**
- **Inhibition of digestive proteases in larval midguts**
    - **Proteinase inhibitor genes**

TRANSFORMATION:

In the last few years, we developed and optimized a number of sugarbeet transformation methods in order to improve the efficiency with which beneficial genes can be introduced into the sugarbeet genome (Ivic and Smigocki, 2001; Ivic and Smigocki, 2003a; 2003b; Ivic et al., 2001a; 2001b; Snyder et al., 1999; Ivic-Haymes and Smigocki, 2004) as we found that methods in the public domain are not readily reproducible and yield low transformation frequencies. Therefore, as a first step for developing a reliable transformation protocol for commercially important sugarbeet lines, we optimized the production of highly embryogenic cells for use with the particle bombardment gene transfer method.

Progress:

Using leaves of greenhouse-grown sugarbeet breeding lines, we determined which plants consistently produced highly regenerative leaf callus. The leaves of these plants were used directly for particle bombardment. The efficiency of transformation, calculated as the number of shoots expressing the gusA (GUS) gene per number of bombarded leaf fragments, ranged from 0.9% to 3.7% (Table 2). The advantages of this transformation method include an abundant source of leaf material from greenhouse-grown plants, the ease of handling leaf material in tissue culture, and the overall rapid regeneration of transgenic shoots within 3 months of bombardment.

Table 2. Results of biolistic transformation of sugarbeet leaf fragments with Osm*-GUS and Pin2*-GUS gene constructs.

Construct	Experiment	KM concentration (mg/l)	Number of bombarded explants	Explants with callus (%)[1]	GUS⁺ callus	GUS⁺ shoots
Osm-GUS	T21	0	34	100[2]	1	0
	T9	0	27	48[2]	1	3
		100	6	0	0	0
Pin2-GUS	T25	0	115	66[2]	1	1
	T12	0	32	100[2]	1	1
		10	3	67[3]	0	0
		20	6	17[3]	0	0
		25	8	50[3]	2	0
		30	8	38[3]	0	0

[1] determined 8 weeks after transformation.
[2] large, friable, yellow callus with shoots
[3] small, friable callus, no shoots.
*Osm – osmatin gene promoter; Pin2 – proteinase gene promoter

INSECTICIDAL COMPOUNDS:

We are exploring the potential use of plant-derived insecticidal compounds for pest control. We discovered that *Nicotiana* plants transformed with the cytokinin biosynthesis gene *ipt* had elevated levels of cytokinins that were correlated with an acquired insect resistance (Smigocki et al. 1993). As cytokinin applications have been linked to the accumulation of secondary metabolites, many of which have insecticidal properties, our studies with transgenic plants that overproduce cytokinin also suggest the involvement of cytokinins in the modulation of secondary metabolic pathways. We demonstrated that most of the insecticidal activity was localized to the leaf surfaces in transgenic *ipt* plants (Smigocki et al. 1997; Smigocki et al. 2000). Tobacco hornworm (Lepidoptera), and green peach aphid (Homoptera) larvae were either killed or their normal development and reproduction were severely affected when exposed to the extracts.

Progress:

Exposure of sugarbeet root maggot larvae to the extracts induced an almost immediate twitching and thrashing behavioral response that was followed by death (Smigocki et al., 2003). We observed that more than 90% of the larvae died after 5 days of exposure to a 1% suspension of the extract (Table 3). Purification of the insecticidal extracts has not proceeded to where biological activity could be ascribed to any one or more of the compounds. Exposure of SBRM larvae to a suspension of a partially purified fraction of the extract induced a similar twitching and thrashing response that was followed by death as was observed with the unfractionated extract. These results suggest that cytokinin-mediated insect resistance could be an effective strategy for control of the sugarbeet root maggot.

Table 3. Effects of surface extracts from transgenic *ipt* and untransformed *N. plumbaginifolia* plants on first-instar SBRM after 1 and 5 days of exposure.

		Mortality (%)		Twitching (%)[1]	
		Day			
		1	5	1	5
Extract/Concentration					
Transgenic *ipt*	1%	0	92	68	42
	0.1%	0	83	10	40
Untransformed	1%	0	23	0	19
	0.1%	0	53	0	20
Saline control		0	26	0	0

[1]Percent of live larvae that were twitching.

Identification of the active compounds in the extracts will help define how cytokinins modulate the production, secretion or availability of these compounds and lead to possible biotechnological approaches for environmentally friendly insect control. As a step towards a better understanding of how cytokinins modulate plant defense mechanisms, we are analyzing cytokinin-induced gene regulation. From a cDNA library enriched for cytokinin-responsive genes, we identified over 100 cDNAs that are up-regulated by cytokinin (Harding and Smigocki, 1994). Included in that set is a gene that codes for a cytochrome P450 monooxygenase, CYP72A2 (Mujer and Smigocki, 2001). Plant cytochrome P450s are heme-containing enzymes that participate in the synthesis of a wide variety of secondary metabolites, some of which are inhibitory to the survival of pathogens and insects. The CYP72A2 gene has sequence homology to a gene that is involved in synthesis of a number of pharmaceutical and insecticidal compounds. We demonstrated that wounding stress and feeding insects systemically induce the expression of CYP72A2. The induction is more rapid in transgenic plants that overproduce cytokinin and in response to insect damage. Metabolic engineering of plants via genetic modification of the P450 enzymes has powerful implications for molecular farming for natural plant chemicals used as pharmaceuticals and disease and insect deterrents.

Progress:

Transgenic plants carrying various constructs of the CYP72A2 gene were regenerated. Most plants appeared to be phenotypically similar to untransformed plants. Preliminary analysis for insect resistance indicated that either over-expression (Figure 1) or suppression of the P450 gene transcript in transgenic plants increased their resistance to insects. Constitutive over-expression of the CYP72A2 gene produced no transformants in tomato, few in Nicotiana tabacum cv. Xanthi, but numerous N. plumbaginifolia transformants (Bartoszewski et al., 2002; Smigocki, unpublished). These results suggest that in heterologous plant systems, CYP72A2 gene expression may need to be stringently regulated to reduce a build up of toxic levels of secondary metabolites that would cause cell death.
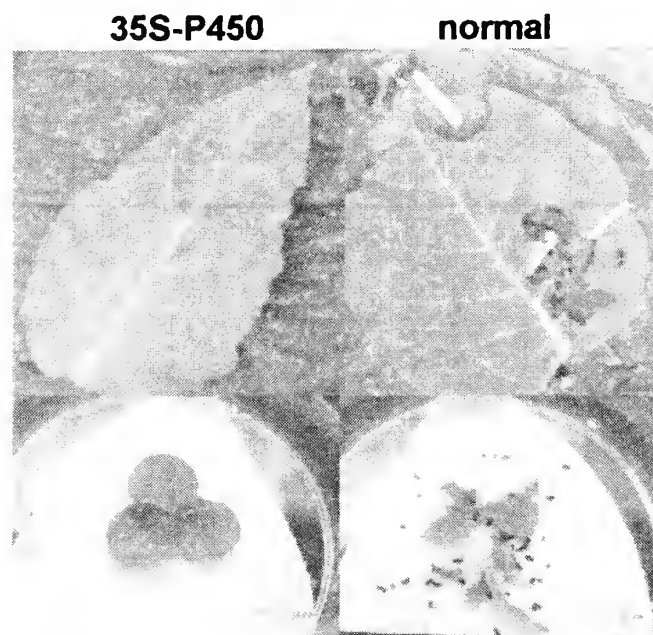
Figure 1. Tobacco hornworm bioassay with tissues from plants transformed with a reconstructed CYP72A2 gene (35S-P450) and normal, untransformed, control plants.

DEFENSE GENE PROFILING:

Gene expression profiling provides new insights into groups of genes whose expression is altered during the interactions of the microbe or insect with the host and for the discovery of cellular genes that were not previously recognized as being regulated by infection or infestation. In addition, analysis of these genes provides knowledge of the regulatory mechanisms that govern plant gene expression and will lead to the development of technologies for controlling gene expression to increase productivity and quality characteristics such as insect/disease resistance in plant germplasm. We initiated studies to characterize the defense response genes of sugarbeet, especially in the sucrose storing taproots that are prone to attack by numerous pests and pathogens.

Progress:
Two breeding lines (F1016 and F1015) released as SBRM resistant germplasm and one parental lines (F1010) (Campbell et al., 2000a) were used to develop a root maggot bioassay for generating infested tissues enriched for resistance genes (Figure 2). Infested tissues were collected at three time points within 48 hr of when larvae were first placed on sugarbeet seedlings and cDNA libraries were prepared from the mRNA extracted from these tissues. The libraries are being screened with a subtracted probe enriched for genes associated with resistance.

Figure 2. A first instar root maggot feeding on a developing taproot of a sugarbeet seedling.

We anticipate that this approach will lead to the identification of sugarbeet clones with potential roles in root maggot and disease resistance. These genes will be characterized and reconstructed for expression in sugarbeet (plants and hairy root cultures) and spinach as a model system in order to analyze their participation in plant defense mechanisms. A microarray panel of sugarbeet genes consisting of the putative resistance-associated cDNA clones and approximately a few thousand additional cDNAs will be prepared. Panels will be analyzed by simultaneous hybridization with probes prepared from the mRNA from infested resistant and susceptible lines, each labeled with a different fluorescent dye. This approach will yield information about groups of genes whose expression is altered during the interaction of the root maggot with the sugarbeet taproot and lead to the discovery of new genes induced by insect infestation.

PROTEINASE INHBITORS (PI genes):

A class of genes that code for proteinase inhibitors (PIs) have been shown to enhance insect resistance in experimental trials (Delledonne et al., 2001; Duan et al., 2001; Samac and Smigocki, 2002). Selected PIs specifically target insect digestive proteases that release essential nutrients from ingested foods. Normal growth and development of the insect depends on this process and, therefore, has been exploited as a target for insect control. In order to determine which PIs might be effective against SBRM, we characterized the major midgut proteases in feeding second instars collected from infested fields in Minnesota (Wilhite et al., 2000). We determined that there are three predominant classes of protease activity in SBRM midgut extracts (Table 4).We tested the effect of several plant-derived PIs on the proteolytic activity (Table 4). Squash aspartyl proteinase inhibitor blocked virtually all the proteolytic activity, confirming the importance of the aspartyl class at acidic pH. Soybean trypsin-chymotrypsin inhibitor (Bowman-Birk I) blocked nearly all proteolysis at pH 8.5, suggesting the presence of trypsin and/or chymotrypsin-like serine proteases in the extract. Similarly, rice oryzacystatin I that targets cysteine proteases blocked approximately 20% of the activity.

Others have reported that a combination of PIs in the insect diets was found to be more toxic at levels where individual inhibitors were not effective. Similarly, higher levels of more than one PI were found in plants that were resistant vs. susceptible to a particular insect (Oppert et al., 1993). These findings suggest that transformation of plants with more than one

Table 4. Digestive proteases in SBRM midguts and class specific proteinase inhibitors that block their activity.

SBRM Midgut Proteases (pH)	Biochemical Inhibitors (% inhibition)	Plant PIs (% inhibition)
Aspartyl 2.5	Peptstatin A (84)	Squash aspartyl (80)
Serine 8.5	PMSF (50)	Bowman Birk I (95)
Cysteine 2.5	E64 (7)	Oryzacystatin I (20)

class of PI genes to target the proteolytic activities in the insect gut will likely prove to be the most effective and sustained means of controlling insect infestations. We identified PI genes with specificity for the aspartyl, serine, and cysteine class of proteases in SBRM midguts that will be introduced into sugarbeet for evaluation of their effect on SBRM larvae.

Progress:

Plant transformation vectors with reconstructed plant PI genes were prepared. To assess the effect of the PI genes, studies were initiated to introduce the genes into sugarbeet hairy root cultures for screening by the SBRM bioassay (Smigocki and Boetel, unpublished). Tissues from

F1016, F1010 and FC609 breeding lines were infected with *Agrobacterium rhizogenes* carrying transformation vectors. Roots that regenerated from the infected tissues are in the process of analysis for the expression of the introduced transgene (*gusA*). Similarly, two spinach lines, as model systems for sugarbeet, are being evaluated for their regeneration potential to identify a line that could potentially be transformed with *Agrobacterium tumefaciens* vectors carrying the PI genes. We have already demonstrated that the root maggot will feed on spinach and similarly plan to assess whether the root maggot larvae will feed on sugarbeet hairy root cultures.

REFERENCES

1. BARTOSZEWSKI, G., MUJER, C. V., NIEMIROWICZ-SZCZYTT, K. & SMIGOCKI, A.: Cloning of a wound inducible *Lycopersicon esculentum* cytochrome P450 gene and lack of generation of transgenic plants with sense or antisense constructs. *J. Am. Soc. Hort. Sci.* 127:535-539, 2002.
2. CAMPBELL, L. G., ANDERSON, A. W. & DREGSETH, R. J.: Registration of F1015 and F1016 sugarbeet germplasms with resistance to the sugarbeet root maggot. *Crop Sci.* 40:867-868, 2000a.
3. CAMPBELL, L. G., EIDE, J. D., SMITH, L.J. & SMITH, G. A.: Control of the sugarbeet root maggot with the fungus *Metarhizium anisopliae. J. Sugar Beet Res.* 37:57-69, 2000b.
4. DELLEDONNE, M., ALLEGRO, G., BELENGHI, B., BALESTRAZZI, A., PICCO, F., LEVINE, A., ZELASCO, S., CALLIGARI, P. & CONFALONIERI, M.: Transformation of white poplar (*Populus alba* L.) with a novel *Arabidopsis thaliana* cysteine proteinase inhibitor and analysis of insect pest resistance. *Mol. Breed.* 7:35-42, 2001.
5. DUAN, X. L., LI, X. G., XUE, Q. Z., ABO-EL-SAAD, M., XU, D. & WU, R.: Transgenic rice plants harboring an introduced potato proteinase inhibitor II gene are insect resistant. *Nature Biotechnol.* 14:494-498, 1996.
6. HARDING, S. A. & SMIGOCKI, A.: Cytokinins modulate stress response in *ipt*-transformed *Nicotiana plumbaginifolia* plants. *Physiol. Plantarum* 90:327-333, 1994.
7. HODGE, K. T., HUMBER, R. A. & WOZNIAK, C. A.: *Cordyceps variabilis* and the genus *Syngliocladium.* Mycologia 90(5): 745-753, 1998.
8. IVIC, S. & SMIGOCKI, A.: Evaluation of the biolistic transformation method for commercially important sugarbeet lines. *Proc. Am. Soc. Sugar Beet Technologists*:207-213, 2001.
9. IVIC, S. & SMIGOCKI, A.: Direct gene transfer to sugarbeet leaves. *Proc. 1ˢᵗ Joint IIRB-Am. Soc. Sugarbeet Tech. Congress*:903-908, 2003a.
10. IVIC, S. & SMIGOCKI, A.: Transformation of sugarbeet cell suspension cultures. *In Vitro Cell. & Develop. Biol. – Plant* 39:5730577, 2003b.
11. IVIC, S. & SMIGOCKI, A.: Biolistic transformation of sugar beet (Beta vulgaris L.) leaves with high regeneration potential. *Plant Cell Reports* (submitted) 2004.
12. IVIC, S., SAUNDERS, J. W. & SMIGOCKI, A.: Leaf callus from sugarbeet breeding lines for biolostic transformation. *Proc. Am. Soc. Sugar Beet Technologists*:214-216, 2001a.
13. IVIC, S., SICHER, R. C., & SMIGOCKI, A.: Growth habit and sugar accumulation in sugarbeet (*Beta vulgaris* L) transformed with a cytokinin biosynthesis gene. *Plant Cell Reports* 20:770-773, 2001b.

14. MUJER, C. V. & SMIGOCKI, A. C.: Wound-inducible cytochrome P450 from *Nicotiana plumbaginifolia. Physiol Plant* 111:172-181, 2001.
15. OPPERT, B., MORGAN, T., CUBERTSON, C. & KRAMER, K.: Dietary mixtures of cysteine and serine proteinase inhibitors exhibit synergistic toxicity toward the red flour beetle, *Tribolium castaneum, Comp. Biochem. Physiol.* 105C:379-385, 1993.
16. SAMAC, D. A. & SMIGOCKI, A. C.: Expression of oryzacystatin I and oryzacystatin II in alfalfa increases resistance to the root-lesion nematode (*Pratylenchus penetans*). *Phytopathology* 91:799-804, 2003.
17. SMIGOCKI, A., NEAL, J. W. JR., MCCANNA, I. & DOUGLASS, L.: Cytokinin-mediated insect resistance in Nicotiana plants transformed with the ipt gene. *Plant Mol. Biol.* 23:325-335, 1993.
18. SMIGOCKI, A. C., CAMPBELL, L. G. & WOZNIAK, C. A.: Leaf extracts from cytokinin-overproducing transgenic plants kill sugarbeet root maggot (*Tetanops myopaeformis*) larvae. *J. Sugar Beet Res.* 40 (3-4):197-207, 2003.
19. SMIGOCKI, A. C., HEU, S. & BUTA, G.: Analysis of insecticidal activity in transgenic plants carrying the ipt plant growth hormone gene. *ACTA Physiol. Plant* 22:295-299, 2000.
20. SMIGOCKI, A. C., HEU, S., MCCANNA, I., WOZNIAK, C. A. & BUTA, G.: Insecticidal compounds induced by regulated overproduction of cytokinins in transgenic plants. In *Advances in Insect Control, The Role of Transgenic Plants*, edited by N. Carozzi and M. Koziel. Bristol: Taylor and Francis, Ltd., 1997.
21. SNYDER, G. W., INGERSOLL, J., SMIGOCKI, A. C. & OWENS, L. D.: Introduction of novel pathogen and defense genes and a cytokinin biosynthesis gene into sugarbeet (*Beta vulgaris* L.) by particle bombardment of *Agrobacterium. Plant Cell Reports* 18:829-834, 1999.
22. WILHITE, S. E., ELDEN, T. C., PUIZDAR, V., ARMSTRONG, S. & SMIGOCKI, A.C.: Inhibition of aspartyl and serine proteinases in the midgut of sugarbeet root maggot with proteinase inhibitors. *Entomol exp appl.* 2000.
23. WOZNIAK, C. A.: Novel fungal pathogen for biocontrol of the sugarbeet root maggot. USA Patent #5,955,071, 1999.

Expression of the *CFP* Gene from *Cercospora* in Sugar Beet

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Plants are known to have various mechanisms for defense against pathogenic microorganisms including structural barriers against infection, production of antimicrobial metabolites and either constitutive or inducible expression of enzymatic proteins (PR proteins) with antimicrobial function. Fungi of the genus *Cercospora* are pathogens of a variety of economically important crops such as sugar beet, tobacco and soybean (*C. beticola, C. nicotianae* and *C. kikuchii*, respectively). The non-host specific phytotoxic polyketide cercosporin is a lipid-soluble perylenequinone that, upon photoactivation, catalyzes the production of highly reactive oxygen species, principally singlet oxygen (Daub 1982). Singlet oxygen-catalyzed peroxidation of membrane lipids results in loss of membrane integrity, cytoplasmic leakage, and cell death (Daub & Ehrenshaft 2000). *Cercospora* hyphae enter the host plant passively through open stomata and grow intercellularly. Toxin-mediated disruption of the cellular membranes of host cells probably provides the pathogen with nutrients for *in situ* growth and sporulation.

Cercosporin-deficient mutants of *C. kikuchii* did not produce lesions on soybean, suggesting cercosporin is an essential virulence factor (Upchurch *et al.* 1991). Recent studies have focused on identifying genes for resistance to cercosporin in *Cercospora* fungi themselves (Daub & Ehrenshaft 2000). One such resistance mechanism apparently involves the export action of the Major Facilitator (MF)-like protein gene, *CFP*, which was isolated from *C. kikuchii* (Callahan et al., 1999). Targeted disruption of the *CFP* gene resulted in mutants that lacked virulence on soybean and were inhibited by cercosporin. Cercosporin export was substantially elevated in *CFP* multi-copy strains of *C. kikuchii* that expressed elevated levels of CFP protein (Upchurch *et al.* 2001). Moreover, transgenic expression of *CFP* in the cercosporin sensitive fungus *Cochliobolus heterostrophus* resulted in significantly increased cellular resistance to the toxin (Upchurch *et al.* 2002).

Kanamycin-resistance clones were regenerated *in vitro* following conjugal mating of wounded REL-1 leaf pieces with *Rhizobium radiobacter* carrying pBCFP. Transgenic plants were confirmed by PCR of leaf DNA using *CFP*-specific primers (Kuykendall, et al, 2003). Moreover, vegetatively propagated kanamycin-resistant plants and seed-grown transgenic REL-1 plants stably maintained the ability to produce a DNA product of the approximate size predicted for PCR using the *CFP*-specifc primers. In this present study, RT-PCR was performed using RNA isolated from *CFP*-transgenic plants and primers suitable for amplifying the entire *CFP* gene to produce the predicted 1.9 kb CFP fungal amplicon from *C. kikuchii*. By RT-PCR of total RNA, the four transgenic plants contained a transcript for *CFP* and DNA sequence analysis of the RT-PCR products confirmed the *CFP* sequence (Kuykendall and Upchurch, 2004). The presence of the intact *CFP* gene as a product of RT-PCR of total cellular RNA clearly indicates active transcriptional expression of *CFP* in transgenic sugar beet plants.

Western blot analysis of total cellular protein, using an affinity-purified polypeptide-specific antibody from rabbit serum, showed the presence of a reactive polypeptide of about 65 kDa (Kuykendall and Upchurch, 2004). That corresponds to the size predicted for the CFP protein which was not observed in parental control plants. Although there may not be an appreciable accumulation, the presence of detectable CFP protein in transgenic sugar beet plants means that the gene was successfully expressed both transcriptionally and translationally.

The *CFP* gene, earlier carried in the pBCFP vector in *Rhizobium radiobacter*, was successfully transferred into sugar beet cells followed by the regeneration of transgenic plants, may provide both cercosporin resistance and pathogen resistance since cercosporin is believed to be critically involved in determining the pathogen's virulence. Although the testing of this hypothesis in transgenic plants has not yet been performed in sugar beet, the expression of the introduced *CFP* gene in sugar beet has been documented using RT-PCR with *CFP*-specific primers and Western Blot analysis with affinity purified peptide specific antibody.

References cited

Callahan TM, Rose MS, Meade MJ, Ehrenshaft M, Upchurch RG (1999)
CFP, the putative cercosporin transporter of *Cercospora kikuchii*, is required for wild type cercosporin producion, resistance, and virulence on soybean. *Mol. Plant-Microbe Interact.* 10:901-910.

Daub ME (1982) Cercosporin, a photosensing toxin from *Cercospora* spp. *Phytopathology* 72:370-374.

Daub ME, Ehrenshaft M (2000) The photoactivated *Cercospora* toxin cercosporin: contributions to plant disease and fundamental biology. *Annu. Rev. Phytpathology* 38:461-490.

Kuykendall LD, Stockett TM, Saunders JW (2003) *Rhizobium radiobacter* conjugation and callus-independent shoot regeneration used to introduce the cercosporin export gene *CFP* from *Cercospora* into sugar beet (*Beta vulgaris* L.). *Biotechnology Letters* 25:739-744.

Kuykendall LD, Upchurch RG (2004) The expression in transgenic sugar beet (*Beta vulgaris* L.) of the toxin export *CFP* gene from *Cercospora kikuchii*, the organism responsible for soybean purple seed stain. *Biotechnology Letters* (in press).

Upchurch RG, Walker DC, Rollins JA, Ehrenshaft M, Daub ME (1991)
Mutants of *Cercospora kikuchii* altered in cercosporin synthesis and pathogenicity. *Appl. Env. Micrbiol.* 57:2940-2945.

Upchurch RG, Rose MS, Eweida M (2001) Over-expression of the cercosporin facilitator protein, *CFP*, in *Cercospora kikuchii* up-regulates production and secretion of cercosporin. *FEMS Microbiol. Lett.* 204:89-93.

Upchurch RG, Rose MS, Eweida M, Callahan TM (2002) Transgenic assessment of *CFP*-mediated cercosporin export and resistance in a cercosporin sensitive fungus. *Curr. Genet.* 89: 179-183.

Characterization of a Fungal Pathogen of the Sugarbeet Root Maggot

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The sugarbeet root maggot (SBRM) remains a highly destructive pest of sugarbeet in North America in essentially all growing areas except the Michigan area and California. Stand losses from early season feeding on the hypocotyl and primary root have been significant in some years with losses attributed to the SBRM reaching into the millions of dollars. Synthetic chemical pesticides, primarily aldicarb, chlorpyrifos, diazinon, phorate and terbufos, have been the primary management tools for managing this pest. Control of this dipteran insect through synthetic insecticides, applied primarily in-furrow, and cultural (*e.g.*, planting date) practices has been effective in many situations, but has been less than consistent. Specific environmental conditions during and after pesticide application, as well as the timing of fly emergence (egg laying) and the level of insect infestation can all contribute to the success or failure of any management program.

There has been additional concerns over the use of persistent, broad-spectrum compounds with respect to environmental hazards (*e.g.*, non-target effects, groundwater pollution) for pest control. The need exists for a biologically-based control agent with reduced-risk properties and an economically plausible control profile. The imperfect fungus, *Syngliocladium tetanopsis*, a naturally occurring pathogen which infects larval root maggots, was discovered in 1994 in the Red River Valley of North Dakota and Minnesota while one of the authors (CAW) was employed with the USDA-ARS in Fargo. The development and application of this organism to SBRM management is the subject of an ongoing investigation.

Laboratory infectivity bioassays using sunflower weevils and beetles, the Colorado potato beetle, tobacco hornworm, green lacewings, house flies, fruit flies and ladybird beetles all indicated that this fungus maintains a fairly restricted host range (*i.e.*, none of these insects were infected). Recent evaluations with the seed corn maggot, also known as the bean seed fly, *Hylemya (Delia) platura* (Diptera: Anthomyiidae), led to infection and mortality with early instars of this dipteran pest. Seed corn maggots (SCM) infested with conidiospores of *S. tetanopsis* were rapidly killed and larvae served as suitable substrates for sporulation and formation of synnemata.

The SCM is a generally a minor pest of sugarbeet, table beet and many vegetable crops as it is often controlled by insecticides applied for control of more significant insect pests. This species is extremely polyphagous and may have up to five generations per season depending on food availability and environmental conditions. The wide host range of this species has, however, made it a considerable problem in organic production systems, particularly in the Pacific Northwest. We are currently working with an organic producer (smallplanetfoods.com) which markets under the Muir Glen and Cascadian Farms labels. SCM have been troubling on sweet corn, table beets, beans, onions, carrots and several other high cash vegetable crops on their organically run farms and they have expressed an interest in seeing *S. tetanopsis* properly evaluated to see if it offers a potential solution. We are hopeful that their interest helps garner enough attention for one or more of the producers of biopesticides to evaluate the economic feasibility of this biocontrol agent.

The preferred delivery vehicle for this biopesticide has yet to be developed, however, testing with barley and maize seed indicates that this fungus will maintain viability for at least 2 years at ambient temperatures following colonization of the sterilized grain. Similarly, culture stabs of oatmeal agar inoculated with conidiospores of *S. tetanopsis* will maintain viable propagules after at least 3 years. While culture of this fungus on a variety of standard or slightly modified fungal media is possible, growth for larger scale production will require culture on an inexpensive nutrient source, such as grain. Nutritional studies with several isolates of *S. tetanopsis* are ongoing and are aimed at enhancing the growth rate and timing of sporulation on artificial and natural substrates.

SUGARBEET RESEARCH

2003 REPORT

Section F

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Genetic variability among isolates of BNYVV and BSBMV and virulence to current Rhizomania resistant cultivars

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Beet Necrotic Yellow Vein Virus (BNYVV) and Beet Soil Borne Mosaic Virus (BSBMV) are closely related viruses found throughout the growing regions of Minnesota and North Dakota. BNYVV infection typically results in rhizomania, which causes reductions in extractable sucrose and yield. Both viruses are vectored by the fungus, *Polymyxa betae* and occupy similar ecological niches. Because of this, the possibility of viral recombination has become an issue. A new virus that can infect BNYVV resistant cultivars like BSBMV, but also cause severe damage like BNYVV would be a threatening combination. In 2002, a strain of BNYVV that could overcome resistance was found in California's Imperial Valley. This new strain puts all of the BNYVV-resistant sugar beet crops at risk because nearly all of them rely on the same gene (Holly) for resistance. By understanding the variability that exists in natural and emerging populations of these viruses, we can evaluate the risk to Minnesota and North Dakota sugar beet growers.

New sources of resistance to BNYVV are needed. Relying on one gene for resistance puts intense selective pressure on BNYVV to overcome it. Traditional methods for determining BNYVV resistance can be inaccurate and time consuming. We hypothesize that real-time PCR could be useful in identifying genetic resistance to BNYVV in cultivars and breeding lines. It could quantify resistance not solely based on the *Rz* gene in a shorter amount of time with a higher degree of accuracy.

Results

Objective 1. Quantify genotypic variation among isolates of BNYVV and BSBMV. Rhizosphere soil from sugar beets with root or foliar symptoms of BNYVV was collected from sugar beets fields in California (CA), Idaho (ID), Michigan (MI), Minnesota (MN), North Dakota (ND) and Texas (TX). BNYVV strain-type controls were obtained from dried sugar beet root tissue infected with BNYVV from Italy (A-type), Japan (A-type), Germany (1 and 2, both B-types), and France (P-type). Rhizosphere soil from sugar beets with foliar symptoms of BSBMV was collected from Colorado (KM, RC, EA), Minnesota (BS, LN, S), North Dakota (Fargo, SH) and Texas (SS, PL, HK). All soil samples were bioassayed in the green house and viral RNA was isolated from baited sugar beet roots. PCR Primers were designed to amplify regions of BNYVV and BSBMV RNA1, RNA2, RNA3, RNA4, and RNA5 (BNYVV only) with PCR. Variability was detected in the replicase portion of the 237 KDa protein (RNA 1), in isolates MN, TX, ID, CA, Italy (A-type control), and Germany1 (B-type control). The replicase protein is responsible for viral replication, so it is possible but unlikely that the variations observed have a significant effect on viral replication because we were able to purify all isolates from sugar beet plants with relative ease. Double bands and size variation were observed in products amplified from the end of the 25 KDa protein (RNA 3). The 25 KDa protein is associated with leaf symptoms and root proliferation and its possible that the genomic variations observed in these isolates affect their symptomology. None of the isolates studied contain an RNA 5 capable of detection with the primers used, indicating that the isolate from the Imperial Valley is either lacking an RNA 5 or it carries one that is significantly different from those observed in the past.

Little or no variation was observed in BNYVV RNA 2 and RNA 4 in the isolates studied. When the BSBMV readthrough protein (RNA 2) was amplified, deletions of approximately 400bp were observed in isolates RC, SH, and PL. Sequence data from the readthrough rt-PCR products confirms 459 bp, 407 bp, and 363 bp deletions in these isolates respectively. The BNYVV 75 KDa readthrough protein has been associated with virus transmission and it is possible that transmission is affected by the deletions in these isolates.

Objective 2. Measure disease tolerance among BNYVV tolerant cultivars by quantitative PCR. Thirty sugar beets, fifteen MonoHy 9155, susceptible to BNYVV, and fifteen Crystal R207, were planted in sand and grown for 10 days. Five seedlings from each variety were then vortexed in 5 ml of a buffer solution with a standard BNYVV isolate, or buffer with the aggressive "CIV" isolate. Seedlings were repotted and grown for another 10 days. Viral RNA was extracted from seedling roots and hypocotyls, and reverse-transcribed to cDNA. The cDNA was amplified with real-time quantitative PCR using primers pairs specific for BNYVV coat protein. As hypothesized, standard BNYVV infection was significantly higher in the susceptible variety (MonoHy 9155) than in the resistant variety (Crystal 207) (Fig. 1). However, infections with the CIV isolate were low in both lines but not significantly different between the susceptible and resistant cultivars (Fig. 1). This response is what one would expect from a virus isolate that had overcome resistance of a resistant cultivar. Seedlings vortexed with PBS by itself were not infected (data not shown). The preliminary results of this study supported our hypothesis that real time PCR could be useful in identifying genetic resistance to BNYVV in cultivars and breeding lines. It could quantify resistance not solely based on the *Rz* gene.

Figure 1. Compared to the susceptible cultivar, MH 9155, virus concentration of the standard BNYVV isolate was significantly reduced in the rhizomania resistant cultivar. However, the CIV isolate was not reduced in the resistant cultivar and virus titer was no different than in the susceptible line. This technique would be an excellent method of quantifying resistance to the new CIV isolate in newly developed germplasm.
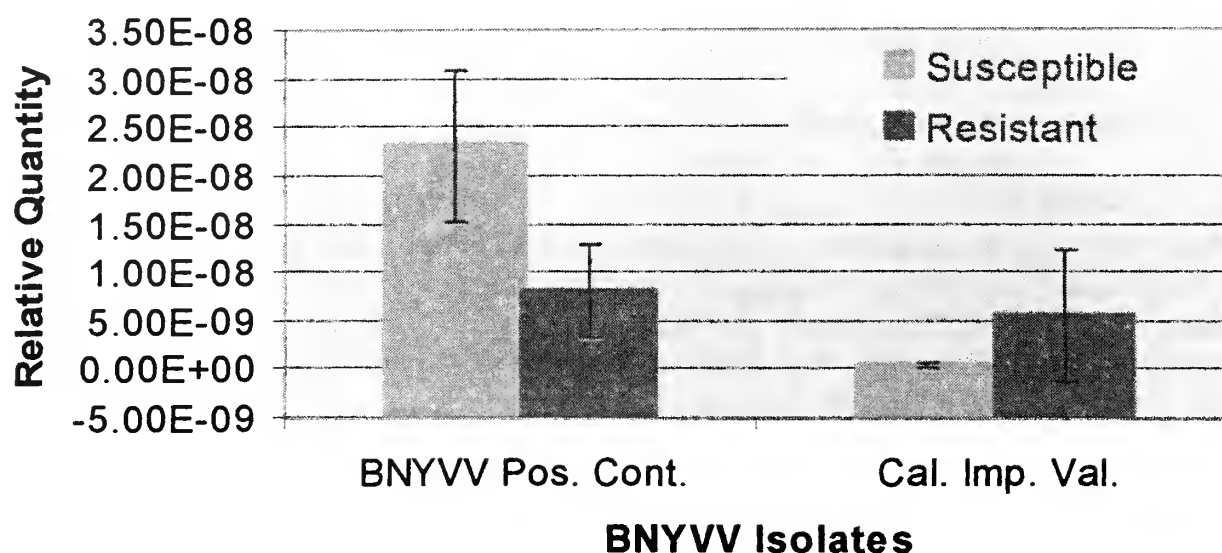
Objective 3. Relate virus genotype (BNYVV and BSBMV) to incidence and severity of infection in resistant and susceptible sugar beet cultivars. Soil from the Imperial Valley of California was planted with seed of the rhizomania resistant cultivar Beta 4776 in order to bait out the "new BNYVV strain", which was designated as the California Imperial Valley "CIV" isolate. ELISA was used to confirm BNYVV infection in these plants and total RNA was isolated. An RNA gel was run to tentatively determine whether the CIV isolate contained a RNA 5 species but no RNA 5 was apparent. Total RNA was reverse-transcribed to cDNA for PCR analysis and subsequent sequencing. Nucleotide sequences of BNYVV from GenBank were compared with the nucleotide sequence of our CIV isolate. PCR Primers specific for the coat protein of BSBMV were used to confirm that RNA isolations from plants infected with the "CIV" isolate of BNYVV did not contain BSBMV RNA. The PCR products generated covered the majority of sequence of each BNYVV RNA. CIV sequences from each individual RNA species were assembled and analyzed using the Lasergene software and the BLAST algorithm (http://www.ncbi.nlm.nih.gov/) (Table 1, 2).

The nucleotide sequence of the CIV isolate was $\geq$ 98% identical to previously published BNYVV sequences. This means that development of a specific probe for this new virus "strain" is likely to be very difficult if not impossible. Furthermore, most of the single nucleotide polymorphisms (SNPs), i.e. differences, observed were insignificant. However some resulted in amino acid substitutions (Table 2). One such substitution ("C" to "T") at nucleotide position 1011 (relative to accession # AF197552) of RNA 4 replaced a tyrosine residue with a histidine residue. Histidine residues are often found in the active sites of enzymes and this change could possibly be responsible for virulence of the CIV isolate to cultivars previously resistant to rhizomania. However, additional research must be conducted to verify this observation.

Table 1. Nucleotide sequence comparison of PCR products from isolate "CIV" with their closest matches in Genbank.

RNA species	# of PCR products	Sequence length	Closest matching sequence in GenBank			Sequence from "CIV" isolate compared with matching sequence in GenBank	
			Accession #	"Type" classification	Length	Nucleotide position	%nucleotide similarity
RNA 2	6	4417 bp	D84411	Type A	4609 bp	137-4553 nt	98%
RNA 3	2	1346 bp	AF197558	Type A	1725 bp	117-1463 nt	99%
RNA 4	2	1129 bp	AF197552	Type A	1416 bp	116-1244 nt	99%

Table 2. Amino acid sequence comparison of putative proteins from isolate "CIV" with their closest matches from GenBank.

BNYVV Protein	RNA species	Nucleotide position*	% amino acid similarity*
Coat Protein (CP)	RNA 2	145-708 nt	100%
Read-throughProtein (RT)	RNA 2	145-2217 nt	99.4%
42K Protein	RNA 2	2130-3284 nt	99.7%
13K Protein	RNA 2	3284-3640 nt	99.2%
15K Protein	RNA 2	3624-4022 nt	98.5%
14K Protein	RNA 2	4034-4423 nt	98.4%
25K Protien	RNA 3	421-1080 nt	99.5%
31K Protein	RNA 4	348-1196 nt	99.6%

Objective 4 (not included in project proposal). Detection and quantification of Beet Necrotic Yellow Vein Virus in soil with real-time quantitative PCR. Traditionally, detection of BNYVV in soil requires a bioassay in which P. betae is baited with sugar beet roots, and BNYVV is then detected by ELISA or conventional RT-PCR methods. Inoculum density can be estimated using the Most-Probable-Number technique which is time-consuming and inaccurate. P. betae has been detected in soil using real-time quantitative PCR, which suggests this method could also be used to detect and quantify BNYVV in soil. Total RNA was isolated from soil infested with viruliferous *P. betae* and was reverse transcribed to cDNA. Primers and probes designed for the coat protein gene of BNYVV were used to detect and quantify BNYVV using real-time PCR. Results indicate this method may be useful in determining inoculum density in field soils used for sugar beet production.

SUGARBEET RESEARCH

2003 REPORT

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Colorado State University
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Progress Report
BEET SUGAR DEVELOPMENT FOUNDATION
FY 2003

Project Title: New Strategies for Modifying Sucrose Distribution in Sugarbeet

Project Number:

Project Leader: Daniel R. Bush   970 491-2442
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        CSU
        Fort Collins CO 80523

Other Personnel Involved: graduate student

Project Location: Biology Department
          Colorado State University, Fort Collins, CO

Justification of Research:

Sucrose accumulated in the sugar beet tap root is synthesized in the leaf and then transported to the root in the phloem cells of the plant's vascular system. The proton-coupled sucrose transport protein mediates the key step in the long-distance transport of newly synthesized sucrose from the leaf to the taproot because it is responsible for sucrose accumulation into the leaf phloem cells and that activity drives sucrose flux to the tap root. We recently discovered a control pathway that regulates the activity of the sucrose transporter and, because of the transporter's role in loading the phloem, this regulatory system appears to control sucrose export from the leaf (Chiou and Bush 1998, Bush 1999). This was a very significant finding because loading the vascular system for sucrose export from the leaf determines how much sucrose is delivered to the tap root. Defining the biochemical and molecular steps involved in controlling sucrose delivery to the beet will allow us to develop new strategies for manipulating productivity.

Recent Progress

We successfully answered three questions posed in experiments funded by BSDF; 1) We showed that down regulation of transport activity is the result of protein degradation. Significantly, the transporter protein turns over very quickly and that appears to be an important part of the regulatory mechanism. 2) We showed that decreased transporter mRNA abundance is the result of down-regulation of gene expression. Taken together with rapid protein degradation, these results tell us that sucrose transport to the tap root is controlled by the abundance of the sucrose transport protein. and 3) We have discovered that regulation of symporter gene expression is mediated by a phosphorylation-dependent signal-transduction cascade. Four manuscripts have been published reporting these results and summarizing the status of the field (Bush and Coruzzi, 2000; Vaughn, Harrington, & Bush, 2002: and Ransom-Hodgkins et al. 2003).

Publications resulting from BSDF support

Coruzzi G and Bush DR 2001. Nitrogen and carbon nutrient and metabolite signaling in plants. *Plant Physiol* 125: 65-68

Vaughn MW, Gregory N. Harrington, and DR Bush 2002. Sucrose-mediated transcriptional regulation of sucrose symporter activity in the phloem. *Proc. Natl. Acad. Sci. USA* 99:10876-10880

Ransom-Hodgkins W, MW Vaughn, and DR Bush 2003. Protein phosphorylation mediates a key step in sucrose-regulation of the expression and transport activity of a beet proton-sucrose symporter. *Planta* 217:483-489

Harrington GN and Bush DR 2003. The bifunctional role of hexokinase in metabolism and glucose signaling. *Plant Cell* 15: 2493-2496

References Cited

Chiou TJ and DR Bush 1998. Sucrose is a signal molecule in assimilate partitioning. Proceedings of the National Academy of Sciences USA 95:4784-4788

Bush DR 1999. Sugar transporters in plant biology. Current Opinion in Plant Biology 2:187-191

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